VOLUME II
FOCUSED FEASIBILTY STUDY
FOR
RICHARDSON FLAT TAILINGS SITE

EPA SITE ID: UT980952840

September 2, 2004

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EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) Report addresses mine wastes at the Richardson Flat Tailings Site (Site) near Park City Utah. This FFS was conducted by Resource Management Consultants, Inc. (RMC) for United Park City Mines Company (United Park), the current owner of the Site. The purpose of this FFS is to provide a focused range of remedial actions for the Site. This document meets the requirements of the National Contingency Plan (NCP) codified in 40 CFR 300.430(e) addressing the alternatives available for the types of wastes at the Site.

The Site is similar in construction and characteristics to other tailings impoundments found throughout Utah and other Rocky Mountain states. The tailings on this Site are non-reactive, and were derived from ore bodies contained in carbonate host rocks. Recent and past investigations show that the tailings are underlain by native high-clay-content soils. The bulk of the tailings lie within a large geometrically closed impoundment which is covered with a vegetated clay-rich low-permeability soil cover. The impoundment is surrounded by two surface water diversion ditches on the north, east and south sides. The west side of the impoundment is contained by an earthen embankment dam (embankment). Because the characteristics of the Site are similar to other tailings impoundments in the Rocky Mountain region, much is known about such sites generally and about the effectiveness of the impoundments' construction. Therefore the proposed remedial alternatives presented in this FFS rely on proven technologies that have been used on other sites in the region.

During the FFS process RMC developed and screened remedial technologies and process options as required by the NCP. This FFS describes the known nature and extent of contamination at the Site with a brief discussion of the potential impacts of site materials.

Remedial action objectives, derived by EPA, are based on site characteristics, risk assessments for human and ecological receptors and current and future land use. The remedial action objectives are summarized below and are discussed in detail in this document.

In general the following Site remedial action objectives were developed for the Site:

- ensure that risks to ecological receptors in the diversion ditch and wetland are mitigated,
- surface water leaving the Site meets applicable water quality standards,
- minimize migration of mine wastes in surface water, ground water and air pathways,
- protect present and future site visitors from exposure to mine waste materials,
- implement institutional controls to protect future land use development and groundwater withdrawal,
- eliminate the risk of catastrophic failure of the tailings impoundment, and
- allow for future disposal of mine waste from the Park City area within the tailings impoundment

After the screening of technologies was completed, five (5) remedial alternatives were developed and selected for detailed analysis. As required by NCP the No Action alternative was included as a remedial alternative. The remedial alternatives evaluated are:

Alternative	Remedial Action	Description
Alternative 1	No Action	Site is left in current condition
Alternative 2	Soil Cover, Institutional Controls, Wedge Buttress	Eighteen inches of clean soil over mine waste areas, institutional controls limiting site use, wedge buttress to increase main embankment stability
Alternative 3	Soil Cover, Source Removal, Wedge Buttress, Institutional Controls	Same as Alternative 2 with source removal in certain areas outside of diversion ditch and the wetland below the embankment.
Alternative 4	Excavate Mine Wastes, Treatment and Offsite Disposal	Complete excavation of mine wastes, treatment to pass TCLP and offsite disposal at an approved facility.
Alternative 5	Excavate Mine Wastes, Treatment and Onsite Disposal	Same as Alternative 4 with onsite disposal

The five remedial alternatives were evaluated using the nine criteria specified by the NCP as follows:

- Overall protection of human health and the environment;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility and volume through treatment;
- Compliance with ARARs;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

A preferred alternative was determined by conducting a comparison based on the first seven of the nine NCP criteria. Based on this comparison the preferred alternative for the Site is Alternative 3. Alternative 3 removes contaminated materials located outside of the impoundment (two areas located south of the diversion ditch and the wetland area located below the embankment), and places them inside of the geometrically closed impoundment, increases the depth of clean cover over contaminated materials, increases stability of the main embankment and mitigates ecological risks in the South Diversion Ditch. This alternative is more protective of the environment than Alternatives 1 and 2 and somewhat less protective of the environment than Alternatives 4 and 5. However, Alternatives 4 and 5 are significantly more costly and technically difficult to implement. The significantly greater costs and difficulties of implementing Alternatives 4 and 5 are not justified by the marginal improvement they offer in regard to public health and environmental protection. The preferred alternative provides adequate protection to human health and the environment at a substantial cost saving over Alternatives 4 and 5.

The overall costs associated with this alternative are estimated to be: $ 4,262,729.65.

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) Report addresses contaminated waters and mine wastes conducted as part of a Focused Remedial Investigation and Feasibility Study (Focused RI/FS) at the Richardson Flat Tailings Site, Site ID UT980952840, (The "Site") near Park City, Utah. The Site is an inactive mill tailings impoundment owned by United Park City Mines Company (United Park). United Park is has prepared this document pursuant to the Administrative Order on Consent (AOC) for a Focused Remedial Investigation/Feasibility Study, dated September 28, 2000, U.S. EPA Docket No. [CERCLA-8-2000-19]. The Focused RI/FS Work Plan (RMC, 2000), as referenced in this report, was approved by the United States Environmental Protection Agency Region VIII (EPA) on September 28, 2000.

This report includes the relevant portions of a Focused Feasibility Study. As requested by EPA, the format of this report contains the elements of a FFS outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA 540/G-89/004, 1988). Section titles follow the suggested outline where applicable.

1.1 Purpose and Organization of Report

The purpose of this FFS is to provide a focused range of remediation alternatives for the Site. The costs and benefits of the remedial alternatives that are feasible, implementable and effective in reducing the risks associated with Site contamination are analyzed in detail in Section 4.0.

This FFS is organized into separate sections, as follows:

Section	Topic
Section 1	Introduction
Section 2	Preliminary Evaluations of ARARs
Section 3	Risk Management
Section 4	Identification and Screening of Technologies

Section 5 Detailed Analysis of Alternatives

Section 6 Selection of the Preferred Alternative

Section 7 References

1.2 Background Information

This section provides a summary of background information for the Site. Detailed Site information including history, previous investigations as well as the nature and extents of contamination can be found in the Focused Remedial Investigation Report (RMC, 2004) for the Site and is summarized below:

The Site is the location of a tailings impoundment located approximately one and one-half miles north of Park City (Figure 1-1). The Site is generally bounded by open lands and State Highway 248 (Figure 1-2). The Study Area Boundary is depicted on Figure 1-3. The Site boundary was determined by reviewing sample results collected during the remedial investigation and determining the location of a boundary that contains surface soils containing less than or equal to a background lead concentration of 114 parts per million (ppm). Tailings at the site are generally covered with at least six inches (6") of clean, low permeability soils.

Surface water at the Site is generally limited to four areas; the wetland area located below the embankment area, the South Diversion Ditch, the pond located at the terminus of the South Diversion Ditch and seasonal ponding on the impoundment (Figure 1-3). The wetland below the embankment, pond and South Diversion Ditch are the only year-round surface water onsite. The Site flows into Silver Creek located to the west of the Site. Seasonal surface water occurs on the impoundment and topographically low area located south of the county road (Figure 1-3), this area drains into the South Diversion Ditch. In general, metals in surface waters are attenuated over the course of the South Diversion Ditch. Water discharging from the Site into Silver Creek contains lower metals concentrations than Silver Creek. Metals concentrations in surface waters found in the northern downgradient portion of the wetland area are affected by Silver Creek.

Ground water impacts at the Site are limited to a near-surface seasonal aquifer. The Site does not appear to be impacting the deeper regional aquifers.

The impoundment is contained on the downgradient (west) side by an earthen embankment. A geotechnical study (Appendix A) indicates that the installation of a wedge buttress will add long-term stability to the embankment.

Baseline ecological and human health risk assessments were conducted for the Site. The ecological risk assessment determined that there is some risk to ecological receptors and limited risk to human Site users.

1.3 Site Description

The Richardson Flat property is owned by United Park and covers approximately 650 acres in a small valley in Summit County, Utah, located one and one-half miles northeast of Park City, Utah (Figure 1-3). The tailings impoundment covers approximately 160 acres in the northwest corner of Richardson Flat and lies within the northwest quarter of Section 1 and northeast quarter of Section 2, Township 2 South, Range 4 East, Summit County, Utah (Figure 1-2). Figure 1-3 shows the Site configuration, topography and boundary.

Information on the Site's physical setting and climate are presented in the Remedial Investigation Report (RMC, 2004) for the Site.

1.4 Anticipated Future Land Use

Anticipated future land uses for the Site include a mixture of open-space and recreational uses. Anticipated recreational uses may include, among others, team sports such as baseball and soccer, golf and equestrian uses. It is also anticipated that portions of the property may be set aside for open space. It is not anticipated that recreational uses and open space are necessarily mutually exclusive.

The impoundment located on the Site is being considered to accept additional mine waste materials, similar to those already on Site, resulting from remedial activities within the Upper Silver Creek Watershed. Such use of the impoundment would be possible under either Alternatives 3 or 5, both of which anticipate leaving some or all of the existing mining wastes in place with appropriate cover.

Proposed land uses for the Site are detailed in Figure 1-4.

1.5 Site History

United Park was formed in 1953, with the consolidation of Silver King Coalition Mines Company and Park Utah Consolidated Mines Company, both publicly traded mining companies at the time. Tailings were first placed at the Site prior to 1950. The mill tailings present at the Site consist mostly of sand-sized particles of carbonate rock with some minerals containing silver, lead, zinc and other metals. While few specific details are known about the exact configuration and operation of the historic tailings pond, certain elements of prior operations are apparent. From time to time, tailings were transported to the Site through three distinct low areas on the southeast portion of the Site. Over the course of time, tailings materials also settled out into these three low areas that were ultimately left outside and south of the present impoundment area as constructed in 1973-74. An embankment constructed along the western area of the Site also appears to have been in place as part of the original design and construction of the tailings pond, but few details are known of the original embankment.

In 1970, Park City Ventures (PCV), a joint venture partnership between Anaconda Copper Company (Anaconda) and American Smelting and Refining Company (ASARCO), entered into a lease agreement with United Park to use the Site for disposal of additional mill tailings resulting from renewed mining in the area. PCV contracted with Dames & Moore to provide construction specifications for reconstructing the Site for continued use as a tailings impoundment (Dames & Moore, 1974). The State of Utah approved PCV's proposed Site operations based on Dames & Moore's design, construction, and operation specifications. Before disposing of tailings at the Site, PCV installed a large, earth embankment along the western edge of the existing tailings impoundment and constructed perimeter containment dike structures along the southern and eastern borders of the impoundment to allow storage of additional tailings (Figure 1-3). PCV also installed a diversion ditch system along the higher slopes north of the impoundment and outside of the containment dike along the east and south perimeter of the impoundment to prevent surface runoff from the surrounding land from entering the impoundment. PCV also installed groundwater monitoring wells near the base of the main embankment, as part of the required approval process by the State of Utah.

PCV conveyed tailings to the impoundment by a slurry pipeline from its mill facility located in Ontario Canyon south of Park City, UT. Over the course of its operations, PCV disposed of approximately 420,000 tons of tailings at the Site. In addition to developing construction specifications for the Site, Dames & Moore also provided PCV with design specifications for the embankment as well as operating requirements for the tailings pond and slurry line, that were also approved by the State of Utah as a requirement for operating the Site. Dames & Moore recommended, among other things, that PCV operate the slurry line in such a way to deposit tailings around the perimeter of the tailings impoundment and moving towards the center of the impoundment (Dames & Moore, 1974 at p. 21). This is a common operating practice in the industry. Unfortunately, PCV failed to follow the Dames & Moore requirement and operated the slurry line in such a way that a large volume of tailings were placed near the center of the impoundment in a large, high-profile, cone-shaped feature and oversteepened the embankment. Between 1980 and 1982, Noranda Mining, Inc. (Noranda) leased the mining and milling operations and placed an additional, estimated 70,000 tons of tailings at the Site. After cessation of operations by Noranda in 1982, the presence of this cone-shaped feature of the tailings pond resulted in the prevailing winds cutting into the tailings and the tailings materials becoming wind-borne. Had the slurry line been operated according to the Dames & Moore specifications, the high-profile tailings cone would not have existed and prevailing winds would not have been a significant potential exposure pathway at the Site.

2.0 PRELIMINARY EVALUATION OF ARARs

This Focused Feasibility Study was developed following the basic methodology outlined in 40 CFR § 300.430 and further discussed in EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (October 1988). Section 121(d) of CERCLA requires that remedial actions comply with state and federal applicable or relevant and appropriate requirements (ARARs), as defined below, unless a waiver is justified under Section 121(d)(4) of CERCLA. ARARs are used to assist in determining the appropriate extent of site cleanup, to scope and formulate remedial action alternatives, and to govern the implementation of a selected response action.

The potential ARARs for the Site in each of the three categories (chemical-specific, location-specific, and action-specific) are summarized in Table 2-1 and discussed below. ARARs identified herein become final upon issuance of a Record of Decision by EPA.

2.1 Definition of ARARs

ARARs, as defined by CERCLA Section 121(d), include any standard, requirement, criterion, or limitation promulgated under federal environmental law, as well as any standard, requirement, criterion, or limitation promulgated by state law that is more stringent that the associated federal standard, requirement, criterion, or limitation. If a state is authorized to implement a program in lieu of a federal agency, state laws arising out of that program constitute ARARs instead of the corresponding federal law.

Response actions occurring on-Site, including those performed in the areal extent of the contamination, must comply with the substantive requirements of ARARs. Response actions performed under CERCLA authority are generally exempt from the administrative requirements of ARARs such as permitting, reporting, record keeping, and consultation requirements, as provided in Section 121(e)(1) of CERCLA.

2.1.1 Applicable Requirements

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. "Applicability" implies that the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of a requirement. Only those state standards that are identified by the state in a timely manner and are more stringent than Federal requirements may be applicable.

2.1.2 Relevant and Appropriate

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site and are well-suited (appropriate) to circumstances at the particular site.

Requirements must be both relevant <u>and</u> appropriate to be ARARs. The relevance and appropriateness of a requirement can be judged by comparing a number of factors, including the characteristics of the remedial action, the hazardous substance in question, or the physical circumstances of the site, with those addressed in the requirement.

It is possible for only part of a requirement to be considered relevant and appropriate. During the FS process, relevant and appropriate requirements have the same weight and consideration as applicable requirements.

2.2 Development of ARARs

ARARs are divided into three broad categories, based on the manner in which they are applied at a site: chemical-specific, location-specific and action-specific requirements.

2.2.1 Development of Chemical Specific ARARs

Chemical specific ARARs are health or risk-based numerical values or methodologies that establish concentration or discharge limits, or a basis for calculating such limits, for particular contaminants, thus establishing acceptable levels for discharge, treatment and disposal of such contaminants against which to assess the effectiveness of remedial alternatives.

2.2.2 Development of Location Specific ARARs

Location specific ARARs are the restrictions on the concentration of hazardous substances or the conduct of cleanup activities for specific locations. For example, ARARs may govern certain cleanup activities located in wetlands, stream beds, historic districts, or archeological sites. Location specific ARARs may restrict or preclude certain remedial alternatives because of the location or characteristics of a particular site.

2.2.3 Development of Action Specific ARARs

Action specific ARARs set controls or restrictions on particular kinds of activities that may relate to the cleanup of hazardous substances. Action specific ARARs are used to establish how a particular remedy may be achieved. Inability to comply with action specific ARARs may indicate that a particular remedial alternative is technically infeasible. Thus, it is not uncommon for action specific ARARs to apply to only some, but not all, of the remedial alternatives.

2.2.4 Other Criteria To Be Considered

To be considered (TBC) criteria consist of non-promulgated standards, advisories and guidance developed by government health and environment programs that are not legally binding, but are intended to provide recommendations.

2.3 Chemical Specific ARARs for the Site

The following chemical specific standards are potential ARARs for the Site:

2.3.1 Utah Water Quality Act Rules

The Remedial Investigation for the Site strongly indicates that the Richardson Flat tailings impoundment is not impacting surface water quality in Silver Creek. Each of the remedial alternatives is designed to maintain or improve surface water quality on the Site. Thus, the definitions and substantive standards of Rule 317-1 of the Utah Administrative Code (implementing the Utah Water Quality Act) are potentially applicable to the remedial alternatives, but are not anticipated to be at issue.

2.3.2 Surface Water Quality

The Remedial Investigation for the Site strongly indicates that the Richardson Flat tailings impoundment is not impacting surface water quality in Silver Creek. Each of the remedial alternatives is designed to maintain or improve the Site. Thus, the substantive requirements of the Utah Surface Water Quality Standards contained in Rules 317-2-6, 317-2-13, and 317-2-14 of the Utah Administrative Code (UAC) are potentially applicable to the remedial alternatives, but are not anticipated to be at issue.

2.3.3 Utah Groundwater Quality Rules

The Remedial Investigation for the Site strongly indicates that the Richardson Flat tailings impoundment is not impacting off-site ground water quality. On-site groundwater in certain areas would not meet drinking water standards, therefore institutional controls would be necessary to limit human exposure of groundwater. Consequently, the substantive ground water quality standards set forth in UAC R317-6 are potentially applicable to the remedial alternatives, but are not anticipated to be at issue.

2.3.4 Identification of Solid and Hazardous Waste

Pursuant to UAC R315-2-4(b)(7), the applicable standard for identifying solid and hazardous wastes, the mine tailings and other materials at issue are considered solid but **not** hazardous waste.

2.3.5 Utah Corrective Action Cleanup Standards Policy

UAC R311-211, providing corrective action cleanup standards for CERCLA sites in Utah, is applicable. Under every alternative, with the exception of the no-action alternative, sources will either be eliminated or appropriately controlled. Because the cleanup is being conducted under federal authority, however, the case-by-case determination of cleanup standards described in UAC R311-211-3 shall be established by the EPA Remedial Project Manager.

2.3.6 Utah Storm Water Rules

Although no storm water permit is required for the remedial alternatives, best management practices are required to minimize off-site impacts from the performance of the remedial alternatives.

2.4 Location Specific ARARs for the Site

2.4.1 Protection of Wetlands

Although the permit requirement of 33 U.S.C. § 1344 inapplicable to the performance of the remedial action, measures to avoid, restore or otherwise mitigate impacts to wetlands are appropriate.

2.4.2 Historic Sites, Buildings and Antiquities Act

16 U.S.C. § 461-67, requiring protection of landmarks listed on the National Registry, is applicable. Because the remedial alternatives will not adversely affect any listed landmark, this requirement is not anticipated to be at issue.

2.4.3 National Historic Preservation

16 U.S.C. § 470, requiring protection of certain historically significant districts, sites, buildings, structures and objects, is applicable. Because the remedial alternatives will not adversely affect any such districts, sites, buildings, structures and objects, this requirement is not anticipated to be at issue.

2.4.4 Archeological and Historic Preservation Act

16 U.S.C. § 469, requiring protection of significant historical and archeological data, is applicable. Because the remedial alternatives will not adversely affect any such data, this requirement is not anticipated to be at issue.

2.4.5 Fish and Wildlife Coordination Act

16 U.S.C. § 662, requiring that actions in streams and rivers be taken in a manner protective of fish and wildlife, is applicable. The United States Fish and Wildlife Service has previously been

consulted regarding potential impacts on fish and wildlife and each alternative could be performed in such a manner.

2.4.6 Endangered Species Act

16 U.S.C. § 1531, *et seq*, requiring protection of endangered and threatened species, is applicable. The United States Fish and Wildlife Service has previously been consulted regarding potential impacts on endangered and protected species and each alternative could be performed in such a manner.

2.4.7 Migratory Bird Treaty Act

16 U.S.C. § 703 *et seq*, requiring protection of migratory nongame birds, is applicable. The United States Fish and Wildlife Service has previously been consulted regarding potential impacts on migratory birds and each alternative could be performed in such a manner.

2.4.8 RCRA Subtitle D Solid Waste Requirements

Although the mine tailings and other materials at Richardson are considered solid waste, the subtitle D landfill requirements found in UAC R315-303 are not applicable because the impoundment area will not be a jurisdictional permitted landfill as provided in the regulations. Although not applicable, the closure requirements set forth in R315-303-3(4) are nonetheless potentially relevant and appropriate in designing the final cover for the impoundment area under Alternatives 3 and 5.

2.4.9 Air Emission Standards

UAC R307-205-6, which requires that controls be established to limit fugitive dust emissions from tailings piles, is applicable.

2.5 Potential Action Specific ARARs for the Site

2.5.1 Abandonment and Construction of Wells

UAC R655-4, providing standards for the abandonment and construction of monitoring wells, is potentially applicable.

2.6 Potential TBC Criteria for the Site

This FFS evaluated relevant TBC in conjunction with ARARs. Although not yet finalized, and therefore not legally binding, the Silver Creek Total Maximum Daily Load (TMDL), which provides target zinc and cadmium concentrations of 0.39 ppm and 0.00076 ppm, respectively, for tributary waters of Silver Creek may be a relevant and appropriate criteria for the remedial alternatives.

3.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) serve as guidelines in the development of alternatives for site remediation. RAOs specify contaminants and media of concern, exposure pathways and potential receptors, and acceptable concentration limits or ranges for each such contaminant or media, pathway and receptor. RAOs are developed to set targets for the Preliminary Remediation Goals established by ARARs or appropriate risk based concentrations.

3.1 Basis and Development of RAOs

RAOs for the Site were based on the risks identified in the Baseline Human Health Risk Assessment (BHHRA) and the Baseline Ecological Risk Assessment (BERA) each conducted by EPA and discussed in detail in the Remedial Investigation report. The Conceptual Site Model (CSM) was also evaluated. The CSM, presented as part of the Sampling and Analysis Plan (SAP) for the Site (RMC, 2001), identified potential complete and incomplete exposure pathways for both on and off-site ecological and human receptors, considering separately tailings located within the impoundment and tailings located outside of the impoundment.

Evaluation of the risk analyses and CSM led to the identification of several key concerns driving the need for, and scope, of any remedial action for any given media of concern. These Remedial Action Drivers are as follows:

3.1.1 Surface Water

The BHHRA determined that surface waters on and leaving the Site present minimal health risk to recreational users of the Site risk due to low concentrations of lead and arsenic, the chemicals of potential concern identified in the BHHRA, as well as the minimal duration of exposure for most Site visitors. The BERA similarly determined that surface waters on and leaving the Site generally presented limited risks to aquatic receptors due to the low levels of the various contaminants of concern identified in the BERA. As discussed in the Remedial Investigation report, however, zinc concentrations in the upper section of the South Diversion Ditch were found to exceed State surface water standards. By the time these waters reached the terminus of the South Diversion Ditch, however, zinc concentrations were below applicable standards. During the Remedial Investigation zinc concentrations at the terminus of the South Diversion Ditch were an order of magnitude below the proposed TMDL target of 0.39 ppm and cadmium concentrations were found to be less than the analytical detection limit of 0.001 ppm. The TMDL target concentration for cadmium is 0.00076 ppm less than the detection limit used during the Remedial Investigation. Detection limits used in the Remedial Investigation were developed and approved in coordination with EPA and the Utah Department of Environmental Quality to evaluate potential exposures to human health and the environment. Although the TMDL process was initiated at about the same time as the Remedial Investigation development of TMDL target concentrations occurred well after the Remedial Investigation was completed, therefore analytical detection limits could not be adjusted during the Remedial Investigation for the TMDL cadmium target of 0.00076 ppm. A standard practice to derive a concentration below the detection limit is to multiply the detection limit by 0.5, using this methodology results in cadmium concentrations of 0.0005 ppm in the South Diversion Ditch which is less than the TMDL target concentration.

Based on these findings, RAOs were developed focusing on the sources and pathways for zinc exposure in the upper section of the South Diversion Ditch.

3.1.2 Groundwater

As discussed in the Remedial Investigation report, groundwater at Richardson Flat does not present a risk to off-site groundwater or surface waters, but contains metals in excess of drinking water standards. Remedial alternatives were developed to address such condition, including alternatives that would provide for source removal or control and the use of restrictions on groundwater withdrawal.

3.1.3 Sediments

Data collected and analyzed in the RI indicate that sediments in the South Diversion Ditch and the wetland adjacent to the main embankment contain elevated levels of lead that may pose risks to aquatic and wildlife receptors. The BERA noted, however, that sediments in the pond near the end of the diversion ditch pose a lesser threat to ecological receptors. Remedial alternatives were developed to address the presence of these sediments, including excavation and removal of contaminated sediments and covering the sediments to form a barrier to ecological receptors.

3.1.4 Soils/mine tailings

Clean soil cover was previously placed over sections of the tailings both in and outside of the impoundment. As discussed in the Remedial Investigation report, risks arising from elevated metals concentrations in tailings and soils were significantly reduced in areas where sufficient soil cover existed over mine tailings.

The BHHRA showed no significant risk to recreational users of the Site from the existing soils and mine tailings. The BERA did not evaluate exposure to soils/mine tailings for ecological receptors. Nonetheless, RAOs were developed to address impacts from tailings and soils located in and around the impoundment area. Because catastrophic failure of the tailings impoundment would change the risks for the site, RAOs were also established to address the oversteepened bank of the tailings impoundment.

3.2 Remedial Action Objectives for the Site

After consideration of the Remedial Action Drivers described above, and after consideration of the ARARs set forth in Section 2.0, the following RAOs were established.

3.2.1 Surface Water

With respect to surface water, RAOs include:

- Reduce risks to wildlife receptors in the wetland area and South Diversion Ditch such that hazard indexes for lead are less or equal to one.
- Ensure that surface water discharged from the Site meets applicable Utah water quality standards.
- Allow for a variety of future recreational uses; and
- Control of contaminant migration in surface water to the extent practical.

3.2.2 Groundwater

With respect to groundwater, RAOs include:

- Eliminate the possibility of future ground water use and withdrawal at the Site; and
- Control of contaminant migration in groundwater to the extent practical.

3.2.3 Sediments

With respect to sediments, RAOs include:

- Reduce risks to wildlife receptors in the wetland area and South Diversion Ditch such that hazard indexes for lead are less or equal to one; and
- Control of contaminant migration in sediments to the extent practical.

3.2.4 Tailings and Soils

With respect to tailings and soils, RAOs include:

- Control of contaminant migration in soils to the extent practical.
- Ensure that recreational users, including children, continue to have no more than a 5% chance of exceeding a blood lead level of 10 micrograms per deciliter from exposure to lead in soils.
- Ensure that recreational users, including children, continue to have no more than 1 x 10-4 chance of contracting cancer from exposure to arsenic in soils.
- Eliminate the risk of catastrophic failure of the tailings impoundment.
- Allow for a variety of future recreational uses.
- Allow for future disposal of mine tailings from the Park City area within the tailings impoundment; and
- Minimize post-cleanup disturbance of tailings and contaminated soil. Provide controls for ensuring any necessary disturbance is controlled.

3.3 Preliminary Remediation Goals

Preliminary Remediation Goals (PRGs) were established to meet the RAOs based on ARARs and the results of the BERA and BHHRA. PRGs generally represent a maximum contaminant level in soils that is deemed protective of human health and the environment on and near the Site.

Because the BHHRA shows no significant risk to human health resulting from recreational users exposure to surface soils, no human health PRGs are necessary for the Site. However, future land use will be controlled to ensure that exposures to mine wastes do not exceed current conditions.

Based on the ecological risks that the sediments containing elevated levels of lead in the wetlands below the main embankment and in the South Diversion Ditch, a PRG of 310 ppm for lead in sediment was determined by EPA. Other than this PRG for lead, consideration of the remedial action drivers indicates that remedial action is required for specific features based upon their physical characteristics and dimensions, not on a concentration profile in specific environmental media.

3.4 Identification of General Response Actions

General Response Actions (GRAs) are categories of actions that may be implemented to satisfy the RAOs. GRAs generally include, but are not limited to, such categories as treatment, containment or disposal. GRAs may be used alone or in combination to provide the most effective and appropriate remedial action alternatives.

GRAs identified to meet the remedial goals for each media and the embankment include:

- No Action
- Institutional Controls
- Waste Isolation (Soil Cover)
- Source Removal (Excavation and Disposal)
- Reinforcement (Wedge Buttress)
- Reconstruction (Build New Embankment Structure)

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Various potential technologies for meeting the GRAs were identified in consultation with EPA. In addition to institutional controls, both *in situ* source treatment or control technologies, as well as *ex situ* treatment and disposal technologies, were identified as potential methods for meeting GRAs.

The following *in situ* remedial technologies were identified:

- Waste isolation
- *In situ* chemical stabilization
- Reclamation and revegetation

The following *ex situ* remedial technologies were also identified:

- Excavation and removal
- Soil washing
- Excavation and treatment with onsite disposal
- Excavation and treatment with offsite disposal

As recommended in EPA guidance, these technologies were then evaluated on the basis of effectiveness, implementability and cost as a means of screening out irrelevant or impractical technologies.

4.1 Institutional Controls

Institutional Controls are defined as non-engineering, administrative, and/or legal controls at a site intended to limit or prevent human exposure to hazardous substances. Site use restrictions in the form of protective covenants attached to the land deed might be used to limit the use or disturbance of soils and sediments that could present risk if left in place on the Site. Protective covenants limiting use of groundwater might also be placed on the Site to limit risks associated with ingestion or contact with contaminated groundwater.

Institutional controls are generally low cost and easy to implement. Their effectiveness largely depends on their enforceability.

4.2 *In situ* Technologies

In situ remedial technologies were evaluated using the three screening criteria of effectiveness, implementability and cost as shown in Table 4-1. Section 4.1.1 discusses waste isolation technology, Section 4.1.2 discusses *in situ* stabilization and Section 4.1.3 discusses reclamation and revegetation technologies.

4.2.1 Waste Isolation Technology

Waste isolation covers a range of technologies including soil cover, soil cap, stormwater runon/runoff controls, clay liners, gravel barriers and french drains.

Soil cover and capping technologies reduce the potential for direct contact with tailings and also reduce contaminant mobility from airborne transport of particulates. Soil cover/capping technologies have been widely accepted at similar sites throughout the west and in particular in Utah.

Portions of the Study Area containing exposed tailings and highly contaminated soils could be covered with six to eighteen inches of clean soil. Alternatively, a soil "cap" could be constructed by placing a geomembrane material over contaminated soils and covering with six to eighteen inches of clean soil.

Both soil caps and covers are easily implemented. Cost for the soil cap would be greater than cost for the soil cover due to the need for additional materials and preparation to install the geomembrane materials. An estimated cost of $5.75 per cubic yard for the placement of a soil cover is based on actual earthmoving costs from the 2003 construction season. This cost is also based on the current onsite availability of stockpiled cover material. Of the two options (cover or cap), a soil cap incorporating the geomembrane material would likely be more effective in reducing leaching potential than the soil cover.

Erosion of the final soil surface of either a cover or cap would be prevented by: 1) revegetating the surface, or 2) as appropriate, covering the soil surface with gravel. Stormwater control technologies would also be necessary to manage stormwater runon and runoff adjacent to and on contaminated areas. Restrictions on excavation below any soil cover or cap would be necessary to protect human and ecological receptors, as would routine inspection of the cover/cap remain.

Stormwater controls such as diversion ditches or swales could also be used independently or in conjunction with cap/cover technologies to divert stormwater away from contaminated zones and reduce infiltration and soil erosion. Stormwater controls are effective at managing stormwater, however, they require some long-term maintenance and attention to detail during the design and implementation. At sites where wastes are left in place and covered stormwater controls are a common practice. Costs to install stormwater controls are moderate and the technology is easy to implement.

Gravel barriers could be used as a final surface on soil covers and caps where vegetation cannot be used or where soil erosion is severe. Gravel placed to a thickness of six to twelve inches could also be used as a waste isolation technology in covering contaminated sediments. Such a gravel barrier would prevent wildlife from ingesting contaminated sediments and, when placed at a thickness of twelve inches, would reduce contact/ingestion of contaminated sediments by micro-fauna (e.g., macroinvertebrates). A gravel barrier would not reduce toxicity, or mobility and volume of contaminants, but the technology is effective at forming a barrier between receptors and contaminated materials. Gravel covers would be easy to implement and have a relative low cost to implement.

This technology was retained for further alternatives analysis.

4.2.2 *In situ* Chemical Stabilization/Solidification Technology

In situ chemical stabilization/solidification technology (S/S) would reduce the mobility of hazardous substances and contaminants in the environment through both physical and chemical methods. Unlike other remedial technologies, *in situ* S/S is intended to immobilize contaminants with the host medium, instead of removing them through chemical or physical treatment. Leachability testing is required to measure the effectiveness of the stabilizing chemicals and there are significant data needs for assessing the technical feasibility of this technology and include parameters specific to the technology. Organic contaminants are the target contaminant group for *in situ* S/S.

In situ S/S technology is well demonstrated and can be applied to most sites. The technology requires standard construction and materials handling equipment competitively found among a number of vendors. Reagents and additives are widely available and are relatively inexpensive industrial commodities. The effectiveness of this technology is limited by the depth of contaminants, future use of the site may be incompatible with the S/S materials, a significant increase in volume of S/S and contaminated waste materials, and additional sampling is required to confirm that the technology was effective on the contaminants. Mobility and toxicity of the contaminated wastes are reduced with this technology, however, there is no decrease in the volume of contaminated materials on the site. Costs on large volume waste sites such as Richardson Flat are likely prohibitive, large volumes of S/S materials would have to be transported to the site. The reagents themselves are relatively inexpensive but deep mixing of the S/S materials may not be practical.

This technology was not retained for further analysis.

4.2.3 Reclamation and Revegetation

Reclamation technologies include reclaiming existing, or constructing new, control structures on a site to protect waste isolation measures such as soil covers, caps and diversion ditches. Revegetation is used in a similar fashion to protect soil covers and diversion ditches from erosion.

Possible reclamation for this Site would include increasing stability of oversteepened existing containment features. Increasing the slope stability of a containment feature would not directly reduce mobility of a contaminant it would prevent failure of the containment feature. Likewise, revegetation would not directly reduce mobility of a contaminant it would reduce erosion of the soil cover/cap and would decrease infiltration through plant uptake and transpiration. Reclamation and revegetation would likely be used in combination with other remedial methodologies.

Revegetation costs at the Site are estimated to be $500.00 per acre. Reclamation earthmoving costs range from approximately $5.75 to $7.50 per cyd is based on actual earthmoving costs incurred on similar projects during the 2003 construction season.

This technology was retained for further alternatives analysis.

4.3 *Ex situ* Technologies

Ex situ remedial technologies were also evaluated using the three screening criteria of effectiveness, implementability and cost as shown in Table 4-1. The following subsections discuss excavation and removal, soil washing, chemical separation, stabilization/fixation, and solidification technologies. The final subsection discusses options for disposal of excavated soil.

4.3.1 Excavation and Source Removal Technology

Excavation and source removal is a well-proven and readily implementable technology, it involves removing contaminated material and either placing it in newly constructed landfill or transporting it to a permitted off-site disposal facility. Some pretreatment may be required to comply with land disposal restrictions (LDRs). The technology is applicable to a wide range of contaminants with no particular target group. Although excavation and removal alleviates the contaminant problem, it does not treat the contaminants.

Excavation and removal is a straight forward technology that is the initial step in all *ex situ* treatments. Vendors are familiar with this technology, it is a labor intensive practice with very little potential for further automation.

Excavation and removal is effective at removing contaminants, by itself, however, it is not effective at reducing the mobility of contaminants. It is easily implemented with standard construction equipment that are readily available. Because the technology is labor intensive, its cost is at the higher end of the scale as compared to *in situ* technologies. Fugitive dusts are a problem with this technology and require diligent management to ensure that contaminants are not spread off-site. On sites where large volumes of contaminants are present duration of construction may present issues with public acceptance. Operations and maintenance costs are typically less for this technology as compared to *in situ* technologies.

Excavation costs for materials located onsite are approximately $5.75 per cyd. These costs are based on costs incurred on similar projects during the 2003 construction season.

This technology was retained for further alternatives analysis.

4.3.2 Soil Washing

Soil washing is a water based process using gravity and in some instances chemical separation of inorganic contaminants, particularly heavy metals. It can be used in combination with other ex situ technologies such as chemical separation and stabilization/fixation. Soil washing incorporates technologies from the mining industry using established methods for mineral processing, ore benefaction, and wastewater treatment. The process removes contaminants in one of two ways by dissolving or suspending the contaminants in a wash solution or concentrating the contaminants through particle size and gravity separation. The technology is best suited for contaminants found in coarse-grained sand and reactive contaminants.

Implementing the soil washing technology is relatively straight forward, however, it does require specialized equipment that the general remediation community may not have at its disposal. It is relatively easy to implement administratively. It is effective at reducing the volume of contaminants, however, the toxicity of the final waste product is likely increased and will require additional treatment.

Soil washing alone does not reduce contaminant toxicity, it requires additional materials handling thereby increasing fugitive dust problems, and additional treatment of residual contaminants is required. This technology reduces the volume of wastes, it does not, in itself reduce the toxicity.

Soil washing was not retained for further analysis.

4.3.3 Soil Stabilization/Fixation

Soil stabilization/fixation (S/F) is an *ex situ* technology in which chemical reactions are induced between a stabilization agent and contaminants to reduce their mobility. The objective of S/F is bind the contaminants and prevent their migration into the environment. The S/F is accomplished by the addition of reagents and rigorous mixing which binds the contaminants within a solid matrix, which reduces the permeability and amount of surface area available for the release of toxic components. S/F technology differs from other types remedial technologies in that the contaminants are immobilized with the existing medium, rather than removing them by chemical or physical treatments.

Four major types of S/F technologics are:

- Cement-based stabilization/fixation
- Pozzolanic stabilization/fixation
- Thermoplastic stabilization/fixation
- Polymer stabilization/fixation

The applicability and effectiveness may be limited by the following factors:

- Environmental conditions that may affect the long-term stability of the immobilized contaminants.
- Some processes or high concentrations of contaminants may result in a significant increase in volume.
- Certain wastes are incompatible with different processes, treatability studics a required.
- Long-term effectiveness has not been demonstrated for some contaminant/ process combinations.

Raw materials used in the more common S/F processes such as fly ash, cement and lime are readably available and relatively inexpensive. Processing equipment is readably available from the construction industry. The volume of materials to treat and the increased volume of the final product will substantially add to the final cost of alternatives using this remedy.

Costs for stabilization are approximately $30.00 per cyd of raw material. The swell factor of the final product is estimated at 1.5.

This technology was retained for further analysis.

4.4 Disposal Options

This section presents technologies applicable to the disposal of excavated materials excavated as part of the source removal options as discussed in Section 4.2.1 as well as the disposal of treated materials discussed in Sections 4.2.2 and 4.2.3. On and off-site disposal options are considered in this FFS. Disposal options are summarized in Table 4.2.

4.4.1 Onsite Disposal

This option is possible where tailings within the impoundment are left in-place and covered and when treated materials are disposed of on-site.

The materials addressed in this section will generally be composed of two types:

- Untreated materials excavated from other onsite area, and
- Treated materials that have been excavated from onsite areas and treated prior to placement.

Untreated materials disposed of onsite would consist of materials already in place in the impoundment and materials excavated from areas outside of the impoundment and transported to the impoundment. The materials would be covered with low permeability soils (Section 4.1.1) and revegetated (Section 4.1.3) at the completion of onsite remedial activities. Stormwater best management practices would be used to maintain the integrity of the soil cover. The low permeability soil cover would effectively isolate the materials from the environment.

Treated material disposed on onsite would be placed onsite and covered with low permeability soils (Section 4.1.1) and revegetated (Section 4.1.3) at the completion of onsite remedial activities. Stormwater best management practices would be used to maintain the integrity of he soil cover.

The equipment required to dispose of materials onsite is available locally. The disposal of untreated material is technically very easy to accomplish. The disposal of treated materials is technically more complicated due to the amount of material to be moved. Administratively this option may require agency approval as a landfill. This would entail permitting the Site as a new single use landfill.

Onsite disposal would reduce transportation costs and logistics and would be less disruptive on the local community.

Costs for onsite disposal of material are approximately $1.50 per cubic yard. This cost is based on the short transport distance and costs incurred on similar projects during the 2003 construction season.

This technology was retained for further alternatives analysis.

4.4.2 Off-site Disposal

Off-site disposal technologies include options for the disposal of both treated and untreated materials. Off-site disposal of site materials may involve the following situations:

- Disposal of treated materials in a Class IV C&D landfill, and
- Disposal of untreated materials in a RCRA Subtitle C landfill.

Treated materials not classified as hazardous waste can be disposed of in a Class IV, construction and demolition debris landfill, so long as treated soil removed from the Site could be determined by TCLP extraction analysis to be non-hazardous. Thus, a sampling program would be necessary to certify that materials leaving he Site are non-hazardous. This option assumes that Site materials would be treated using one of the options specified in Section 4.2.

Disposal costs of this option are approximately $30.00 dollars per cyd with a transportation cost of approximately $30.00 per cyd to the East Carbon Landfill. This option would require the transportation of over 10,000 truckloads of materials.

Materials classified as hazardous waste would have to be disposed of in RCRA Subtitle C (hazardous waste) landfill facility. From a technical standpoint, this could be an effective disposal remedy. However, due to the large amount of material located on the Site, high disposal costs at this type of facility (approximately $225.00 per cyd) and the logistics of transporting over 10,000 truckloads of material, this option was not retained for further analysis.

4.5 Surface and Groundwater Technologies

Surface and groundwater treatment reduces and /or removes contaminants from Site waters using chemical or biologic methods. Surface and groundwater treatment options include both active and passive treatment technologies. Both active and passive treatment technologies have the potential to improve surface and groundwater conditions at the Site. The following technologies are potentially applicable for treating metals impacted water at the Site.

Active treatment methods can include:

- Oxidation
- Neutralization/Precipitation
- Biological Treatment
- Separation
- Electrochemical

Passive treatment methods can include:

- Constructed Wetlands
- Anoxic Limestone Drains
- Land Application
- Sedimentation
- Evaporation

The above specified active and passive treatment methods all require substantial operation and maintenance. Pilot testing would be required to assess which methods would be applicable to Site conditions. All of the above specified treatment methods would likely be used as primary treatment systems unless the results of pilot testing indicate that pretreatment is required.

Technically water treatment is an effective remedy with high operation and maintenance requirements. Due to the relatively low concentrations of metals in Site surface and groundwater dispersed over multiple areas, water treatment systems would involve components capable of moving water from multiple locations to a centralized treatment area. Initial capital costs for both active and passive systems would be high. Many of the above specified systems would produce a byproduct that may have to be disposed of as a hazardous material, adding further costs and logistical complications to the method. In summary surface and groundwater treatment is not a cost effective remedy for the Site.

Surface and groundwater treatment was not retained for further analysis.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This Section presents detailed analysis of alternatives required by the NCP in 40 CFR 300.430 (e)(9). The analysis is performed for the alternatives retained after the screening process (Section 4).

The alternative evaluations include descriptions of the technology, the process option selected and assumptions that were necessary to evaluate each alternative. The potential remedial options have been evaluated against seven of the nine NCP criteria. The remaining two criteria, state (or support agency) acceptance or community acceptance will be considered by EPA and UDEQ after the public has had an opportunity to review and comment on the Proposed Plan.

The detailed analysis presented in this Section applies nine criteria to the retained alternatives appropriate for achieving the remedial action objectives for the protection of human health and the environment. The NCP criteria are:

Overall protection of human health and the environment - Alternatives shall be assessed to determine whether they adequately protect human health and the environment from unacceptable risks both short and long term by eliminating, reducing, or controlling exposures to contaminants.

Compliance with ARARs - - Alternatives shall be assessed to determine whether to determine whether they attain federal and state ARARs or provide grounds for invoking a waiver.

Long-term effectiveness and permanence - - Alternatives shall be assessed for long term effectiveness and permanence they provide and the degree of certainty they will prove successful. The following factors shall be considered: (1) magnitude for residual risk remaining after the alternative is implemented and (2) adequacy and reliability of the controls necessary to manage the contaminants.

Reduction of toxicity, mobility, volume through treatment - Alternatives shall be assessed to determine the degree to which recycling or treatment is expected to reduce the toxicity, mobility and or volume of the waste or residual contaminants and the degree to which that treatment is irreversible. The quantity, persistence, toxicity, mobility and propensity to bioaccumulate of each type of residual that will remain after treatment will also be considered.

Short-term effectiveness - Alternatives shall be assessed to determine the short-term impacts during implementation and time until protection is achieved. The impacts that shall be considered include risks to the community, impacts on workers, and potential environmental impacts.

Implementability - Alternatives shall be assessed for the ease or difficulty of implementation, including technical feasibility, administrative feasibility, and the availability of services and materials.

Cost - Alternatives shall be assessed to determine direct and indirect capital costs, annual operation and maintenance costs, and net present value.

State (support agency) acceptance - Alternatives shall be assessed to reflect the state's apparent preferences or concerns regarding the alternatives.

Community acceptance - Alternatives shall be assessed to reflect the community's apparent preferences or concerns regarding the alternatives.

The following five alternatives for mitigating risks at the Richardson Flat Site are presented and analyzed in detail:

- Alternative 1 - No Action
- Alternative 2 - Soil Cover, Institutional Controls and Wedge Buttress
- Alternative 3 - Source Removal, Soil Cover, Institutional Controls and Wedge Buttress
- Alternative 4 - Excavation, Treatment and Offsite Disposal
- Alternative 5 - Excavation, Treatment and Onsite Disposal

With the exception of the no action alternative, the selected alternatives are effective for the protection of human health and the environment at the Site. The proposed alternatives are based on proven existing technologies that have been used at similar sites throughout the Rocky Mountain area. A summary of remedial alternatives is presented in Table 5-1. Table 5-2 presents a comparative summary based on NCP evaluation criteria for the five alternatives. Table 5-3 details the estimation of material volumes used in this FFS.

5.1 Alternative 1 – No Action

The "No Action" alternative is a requirement of CERCLA and the NCP and must be considered for all CERCLA sites. The No Action alternative does not provide any additional protection of human health or the environment. This alternative is designed to establish a baseline of current conditions at the Site to which other alternatives can be compared. Alternative 1 is summarized in Table 5-1 and the evaluation criteria are summarized in Table 5-2.

5.1.1 Overall Protection of Human Health and the Environment

Alternative 1 does not reduce human or ecological risk at the Site. Both human and ecological risk will remain as it is now. As determined by the BHHRA (SRC, 2002) arsenic related non-cancer risks are below a Hazard Index of 1, additionally all cancer risks were estimated to be within or below EPA's acceptable risk range. Risk calculations for lead predict that blood levels for recreational visitors will be below 5% probability of exceeding a blood lead level of 10 ug/dL. Based on these results, Alternative 1 would be a viable alternative to protect human health at the Site. Alternative 1 would not change the current status of environmental conditions at the Site and therefore would not decrease the risk to ecological receptors at the site.

5.1.2 Compliance with ARARs

There is no mechanism for achieving ARARs under this alternative. It should be noted, however, that non-compliance under this option would be limited to specific areas such as the upper South Diversion Ditch and wetlands areas. Location and action-specific ARARs do not apply because no remedial action is involved (Table 2-1).

5.1.3 Long-term Effectiveness and Permanence

Alternative 1 provides no additional control over Site contaminants and long term control of contamination would be unreliable and inadequate. However, based on the conclusions of the RI (RMC, 2004) the Site is not currently discharging contaminants off-site.

The South Diversion Ditch is currently a functioning bioremediation unit and is likely to remain effective if it is not disturbed. Sediments in the ditch, however, are contaminated with metals and the BERA shows elevated risks to avian receptors from the ingestion of contaminated sediments. Surface water quality in the South Diversion Ditch is well within applicable water quality standards at the terminus of the ditch.

Soil cover at the site is generally sufficient to prevent the offsite migration of tailings. The low relief of the Site is a sufficient preventative to prevent large-scale erosion of the soil cover. In its current configuration the Site has not undergone severe erosion and if the Site remains in its current condition it is anticipated that erosion will not occur.

5.1.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 1 provides no reduction in the toxicity, mobility or volume of contaminants. Therefore, Alternative 1 does not satisfy statutory preference for treatment.

5.1.5 Short-Term Effectiveness

Implementing Alternative 1 does not increase the short-term risk to the surrounding area from remedial actions. Because there is no remediation under Alternative 1, there is no short-term risk to the surrounding community or remedial workers. The impacts to the environment remain unchanged from current conditions. Since no remediation occurs, the time until remedial action is not applicable.

5.1.6 Implementability

Alternative 1 does not require the implementation of any remedial options or monitoring.

5.1.7 Cost

There are, by definition, no capital or O&M costs associated with Alternative 1. Therefore, there are no costs with this alternative.

5.2 Alternative 2 – Soil Cover, Institutional Controls and Wedge Buttress

Alternative 2 entails increasing the depth of cover over tailings in the Study Area, implementing institutional controls to manage human contact with Site materials, and installing a wedge buttress to a portion of the main embankment of the tailings impoundment. The South Diversion Ditch and wetland areas will be left undisturbed. A design schematic for Alternative 2 is presented in Figure 5-1. Alternative 2 is summarized in Table 5-1 and the evaluation criteria are summarized in Table 5-2.

The soil cover will be increased in areas where the existing cover is less than eighteen inches thick. Clean soil consisting of low-permeability clay-rich soils will be placed on the existing cover to within six inches of the final surface. The final six inches of cover will consist of topsoil suitable to support vegetation. The south half of the impoundment contains an existing cover of appropriate thickness, the north half of the impoundment would require additional soil cover. The soil cover would be graded to direct stormwater and surface runoff towards the South Diversion Ditch. A drainage channel would be constructed within the impoundment that would divert surface water from the low-lying northern portion of the impoundment into the South Diversion Ditch. The drainage channel will reduce infiltration of surface water into the tailings. Institutional controls will be established to limit future Site use to activities that will not disturb the soil cover, restrict ground and surface water uses, and ensure that long-term maintenance measures are implemented.

5.2.1 Overall Protection of Human Health and the Environment

Placing additional clean soil on the Site would increase the overall protection of human health and ecological receptors. The soil cover would reduce direct contact, ingestion, inhalation and offsite migration of contaminants.

Alternative 2 meets the threshold criteria of protection of human health, however all of the contaminated material is left in place. The contaminated material left in place may be exposed if the soil cover is disturbed by excavation, erosion or construction activities. For Alternative 2 to be effective, institutional controls must be implemented to maintain the integrity of the soil cover. Alternative 2 is not completely effective for the reduction of ecological risk. The cover would not modify existing environmental conditions in the diversion ditch or wetlands.

5.2.2 Compliance with ARARs

Currently, surface water leaving the Site meets applicable water quality standards. Thus, surface water quality ARARs would be met by this alternative. The soil cover and drainage channel will likely reduce seasonal contaminant levels in on-site groundwater, including ground water in the upper South Diversion Ditch area. Institutional controls would also be necessary to mitigate human exposure to on-Site groundwater. Remedial activities would be conducted to comply with location and action specific ARARs.

5.2.3 Long-Term Effectiveness and Permanence

The eighteen (18) inch thick soil cover proposed in Alternative 2 provides a barrier between potential receptors and the underlying contaminated material, therefore achieving long-term effectiveness and permanence. The soil cover will decrease infiltration of surface water into the tailings materials. Lead and arsenic, in the tailings, remain in-place resulting in residual contamination below the soil cover. Institutional controls will be necessary to ensure that the soil cover is not breached and that Site users are educated about maintaining the integrity of the soil cover. If the soil cover is breached during Site construction or use new potential exposure pathways may develop. Contaminated material excavated during onsite construction activities will have to be managed to prevent contamination of the cover.

5.2.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 2 does not provide for the treatment of contaminated material, therefore there is no reduction in the toxicity and volume of contaminated material. The mobility of the material due to wind and water erosion is reduced. The soil cover will effectively mitigate exposure, inhalation, and ingestion pathways. The irreversibility of the treatment process is not applicable since no treatment process is used. The statutory preference for treatment is not met by Alternative 2 since no treatment processes are used.

5.2.5 Short-Term Effectiveness

The soil cover and wedge buttress could be installed in one or two construction seasons. The soil cover and wedge buttress effectiveness would be immediate for pathways noted in the previous section. Institutional controls would be in place within a short time period and therefore effective immediately. The soil cover will reduce stormwater and snowmelt contact with tailings and therefore, over time, reduce metals concentrations in the diversion ditch and groundwater.

5.2.6 Implementability

Remedial activities included in Alternative 2 (standard soil excavation, grading, hauling, backfilling and compaction) are easily implemented. Remedial contractors can provide the necessary equipment and expertise to implement this alternative. The material handled during Alternative 2 will consist primarily of clean soils, handling of contaminated materials will be minimized. Sufficient amounts of clean, low-permeability soil are currently stockpiled onsite. Institutional controls will have to be approved by the applicable regulatory agencies.

5.2.7 Cost

The estimated costs for Alternative 2 as detailed in Table 5-4 are $ 2,295,397.99. The proposed costs include fifteen (15) years of operation and maintenance (O&M) costs.

5.3 Alternative 3 – Source Removal, Soil Cover, Institutional Controls and Wedge Buttress

Alternative 3 includes source removal and covering of tailings located outside of the impoundment, placing clean soil over the tailings impoundment as described in Section 5.2, installation of a wedge buttress, covering of contaminated sediments in the diversion ditch, removing contaminated sediments in the wetland, and placement of restrictions on future land and groundwater use. Based on data collected during the RI, source areas have been identified where tailings would be removed, placed in the impoundment and covered with clean soil. Areas of tailings that pose a low threat to the environment would be covered. These areas would be defined during remedial design. As described in Section 5.2, a wedge buttress would be constructed at the toe of the main embankment. Twelve (12) inches of gravel would be placed over contaminated sediments in the diversion ditch forming a barrier between the sediments and potential human and ecological receptors. The wetland at the terminus of the diversion ditch would be remediated after upstream sources in Silver Creek have been remediated. A design schematic for Alternative 3 is presented in Figure 5-2. Alternative 3 is summarized in Table 5-1 and the evaluation criteria are summarized in Table 5-2.

Under this alternative a portion of the impoundment may be used as a repository for similar materials from other sites within the Park City area. These materials would be placed in low-lying areas on the northern portion of the impoundment where the existing soil cover is less than one-foot thick. Upon completion of tailings emplacement, the area will be covered with clean soil and regraded to direct stormwater and snowmelt runoff towards the diversion ditch. All areas that are remediated will be contoured and revegetated to prevent erosion.

5.3.1 Overall Protection of Human Health and the Environment

Removal of tailings outside of the impoundment eliminates the risk to human and ecological receptors in these areas. Soil cover on the impoundment reduces human health risk by preventing direct contact, ingestion, inhalation and offsite migration of contaminants. The soil cover and associated vegetation would prevent wind and water erosion, thereby, controlling the spread of contamination from the impoundment area. Addition the soil cover would reduce infiltration of surface water into areas that contain mine wastes, this would further decrease groundwater impacts and improve environmental protection at the Site. Contaminant sources outside of the impoundment would be removed and/or covered substantially improving the overall environmental quality of the Site. Covering sediments in the diversion ditch and removing contaminated sediment in the wetland would reduce and remove risks to ecological receptors.

Alternative 3 meets the threshold criteria the protection of human health for both the impoundment and areas outside of the impoundment, however all of the contaminated material is left in place within the impoundment. The contaminated material left in place may be exposed if the soil cover is disturbed by excavation, erosion or construction. For Alternative 3 to be effective, institutional controls must be implemented to maintain the protection of human health and the environment within the impoundment.

5.3.2 Compliance with ARARs

Compliance with chemical specific ARARs (Table 2-1) would be achieved under this alternative. Remediation procedures would be designed to comply with action and location specific ARARs (Table 2-1).

5.3.3 Long-term Effectiveness and Permanence

The long-term and permanence of Alternative 3 is divided into two areas: within and outside of the impoundment. Tailings would be removed from areas of significant contaminant sources outside of the impoundment, remaining areas would be covered with a low permeability soil cover. The long-term and permanence of Alternative 3 in the source removal area is completely effective. The eighteen (18) inch thick soil cover for the impoundment proposed in Alternative 3 provides a barrier between potential receptors and the underlying contaminated material. The tailings are left in-place forming residual contamination in the impoundment below the soil cover. The contamination remaining at the Site in Alternative 3 would be either covered or located in a condensed, centralized location within the geometrically confined impoundment. Institutional controls would have to be implemented to insure that the impoundment soil cover is not breached and that Site users are educated about maintaining the integrity of the soil cover. If the soil cover is breached during Site construction or use new potential exposure pathways would develop. Contaminated material excavated from the impoundment during onsite construction activities would have to be disposed of as hazardous waste. Contaminated material would remain in the South Diversion Ditch, however, the sediments would be covered reducing threats to ecological receptors.

With the exception of the upper South Diversion Ditch area, it does not appear that current conditions are impacting surface or groundwater quality. Under this alternative, surface water would be improved and groundwater quality would likely improve over time, but institutional controls may be necessary to mitigate human exposure.

5.3.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 3 does not provide for treatment of contaminated material, therefore there is no reduction in the toxicity and volume of contaminated material. The mobility of the material due to wind and water erosion is reduced. The soil cover reduces exposure pathways related to direct exposure, inhalation and ingestion. The degree of potential exposure is reduced by removing contaminated materials from locations outside of the impoundment and placing them inside of the geometrically confined impoundment. This would reduce the size of the impacted areas and the extent of contamination in contact with the environment. The irreversibility of the treatment process is not applicable since no treatment process is used. The statutory preference for treatment is not met by Alternative 3 since no treatment processes are used.

5.3.5 Short-Term Effectiveness

Access is controlled by fencing and gates. There are illegal trespassers who use parts of the Site southeast of the impoundment; their risk would be decreased by this alternative. No waste materials would be transported on public roads therefore traffic concerns are not expected. Worker safety would be protected following applicable State and Federal (OSHA) regulations. The time until action is complete may be slightly greater than Alternative 2 and less than Alternatives 4 and 5.

5.3.6 Implementability

Remedial activities outlined in Alternative 3 include standard soil excavation, grading, hauling, backfilling and compaction techniques. All of the proposed activities include, but are not limited to, excavation, transportation, grubbing, grading and revegetation can be provided by local contractors. Site workers would be certified in hazardous material safety. United Park has stockpiled sufficient amounts of clean, low permeability topsoil onsite all other materials are readily available from local and regional vendors.

Institutional controls would have to be approved by the applicable regulatory agencies.

5.3.7 Cost

The estimated costs for Alternative 3 as detailed in Table 5-5 are $ 4,262,729.65. The proposed costs include fifteen (15) years of operation and maintenance (O&M) costs.

5.4 Alternative 4 – Excavation, Treatment and Offsite Disposal

Alternative 4 Excavation, Treatment and Offsite disposal entails the complete removal of contaminated material from the Site. A design schematic is presented in Figure 5-3. Contaminated material would be stabilized onsite and disposed offsite in a landfill. The type of landfill would be dependent on hazardous waste characterization of the excavated materials. Two potential disposal scenarios or a combination of are possible in Alternative 4: 1) Treatment and Disposal in a construction and debris (C&D) landfill or 2) Disposal in a Subtitle C hazardous waste landfill. The material to be disposed of would be tested using the TCLP methodology. SPLP testing conducted for the RI (RMC, 2002) indicates that the material has the potential to leach metals and therefore it is likely that the materials would fail TCLP testing and would be classified as hazardous waste. Prior to treatment bench-scale treatability testing would be conducted to determine the applicability and efficiency of the treatment process. Hazardous materials, from the Site, would be treated prior to disposal at a permitted landfill.

Material would be excavated from areas outside of the impoundment area. A temporary treatment facility would be set up adjacent to the impoundment. The treatment plant would stabilize the material using flyash and/or Portland cement. The treated material would be tested to insure that TCLP results would be below the regulatory levels required for disposal in a non-hazardous waste (C&D) landfill. The East Carbon Development Corporation (ECDC) located 140 miles from the Site in East Carbon, Utah is the nearest C&D landfill with sufficient capacity. Material that does not pass regulatory standards would be disposed of in a Subtitle C (hazardous waste) landfill. Clean Harbors' Grassy Mountain Facility located 120 from the Site in Tooele County, Utah is the nearest Subtitle C landfill with sufficient capacity. Upon the completion of treatment and disposal activities the Site would be reclaimed. The reclamation procedure would entail regrading the site to the configuration of the preexisting topography, where possible, the placement of a six (6) inch thick topsoil layer and revegetation. The current embankment would be removed during reclamation.

5.4.1 Overall Protection of Human Health and the Environment

The excavation and removal of the contaminated material from the Site eliminates human health and ecological risks due to direct contact, inhalation or ingestion of contaminated materials.

5.4.2 Compliance with ARARs

Compliance with chemical specific ARARs (Table 2-1) would be achieved under this alternative. Remediation procedures would be designed to comply with action and location specific ARARs (Table 2-1).

5.4.3 Long-term Effectiveness and Permanence

This alternative achieves the statutory preference for treatment of contaminated materials. The treatment process would chemically and physically stabilize the metals prior to shipment to a waste disposal facility. This would reduce the potential for the metals to leach into the environment. The long-term effectiveness would be achieved since the contaminated material is completely removed from the Site. Residual risks from the materials would be limited to the risks at the disposal facility, these risk are reduced by treatment of the materials.

With the exception of the upper South Diversion Ditch area, it does not appear that current conditions are impacting surface or groundwater quality. Under this alternative, surface water would be improved and groundwater quality would likely improve over time.

5.4.4 Reduction of Toxicity, Mobility or Volume Through Treatment

The toxicity and mobility of Site contamination would be reduced by the removal of contaminated materials and treatment process proposed by Alternative 4. Site toxicity would be further reduced by the disposal of material in a regulated offsite landfill disposal facility. Some material toxicity would remain however, this material would be located in a regulated landfill and that is designed to meet applicable requirements.

The volume of contaminated materials would increase due to the addition of stabilization materials such as flyash or Portland cement.

5.4.5 Short-Term Effectiveness

Short-term effectiveness of Alternative 4 would be dependent on the measures taken to reduce human and ecological exposure during remedial activities. Applicable regulations governing fugitive dust emissions would be followed during all Site activities. The remedial process would be designed to reduce exposures to human health and the environment. There would be elevated short-term risks associated with transporting the treated materials to a disposal facility. These risks are related to traffic accidents and transportation of large volumes of material over long period of time.

5.4.6 Implementability

Remedial activities proposed by Alternative 4 include standard soil excavation, grading, hauling, backfilling and compaction techniques. All of the proposed activities include, but are not limited to, excavation, transportation, grubbing, grading and revegetation can be provided by local contractors. Site workers would be certified to handle contaminated materials. Local contractors are available to provide this service. The stabilization of contaminated materials would be more difficult to implement, however stabilization is a well-established technology. Waste characterization and treatability studies would have to be conducted prior to full-scale implementation. Disposal facilities would have to be arranged prior to the start of remedial activities. Transportation services are readily available. United park has stockpiled sufficient amounts of clean, low permeability soil onsite for final reclamation.

5.4.7 Cost

The estimated costs for Alternative 4 as detailed in Table 5-6 are $ 343,234,057.85 The proposed costs include fifteen (15) years of operation and maintenance (O&M) costs.

5.5 Alternative 5 – Excavation, Treatment and Onsite Disposal

Alternative 5 Excavation, Treatment and Onsite Disposal entails the excavation and treatment of contaminated material from the Site. The treated material would be disposed in an onsite repository in the impoundment area. A design schematic is presented in Figure 5-3. The type of treatment would be dependent on results of treatability studies. Contaminated material would be excavated from areas inside and outside of the impoundment area. Initially a portion of the impoundment would be excavated to provide repository space for treated materials. A temporary treatment facility would be set up adjacent to the impoundment. The treatment plant would stabilize the material using flyash and/or Portland cement. Upon completion of treatment and disposal activities the Site would be reclaimed. The reclamation procedure would entail regrading the Site to a configuration that would provide optimal stormwater drainage off of the repository. Upon completion of remedial activities a twelve (12) inch layer of clean, low permeability soil would be placed on the repository. Areas outside of the impoundment would be regraded to approximate preexisting topography where possible. The site would be covered with a six (6) inch thick topsoil layer and revegetated with a native seed mix. The current embankment would be removed during reclamation.

5.5.1 Overall Protection of Human Health and the Environment

The excavation and treatment of the contaminated material at the Site eliminates the human health and ecological risks due to direct contact, inhalation or ingestion of contaminated materials.

5.5.2 Compliance with ARARs

Compliance with chemical specific ARARs (Table 2-1) would be achieved under this alternative. Remediation procedures would be designed to comply with action and location specific ARARs (Table 2-1).

5.5.3 Long-term Effectiveness and Permanence

This alternative would meet the statutory preference for treatment of contaminated material. The treatment process would chemically and physically stabilize the metals prior to disposal in the onsite repository. This would reduce the potential for the metals to leach into the environment. Long-term effectiveness for the Site is excellent since the contaminated material is stabilized. Residual risks from the materials would be limited to risks of treated materials these risks are minimized by treatment that reduces the leachability of the materials.

With the exception of the upper South Diversion Ditch area, it does not appear that current conditions are impacting surface or groundwater quality. Under this alternative, surface water would be improved and groundwater quality would likely improve over time, but institutional controls may be necessary to mitigate human exposure.

5.5.4 Reduction of Toxicity, Mobility or Volume Through Treatment

This alternative reduces toxicity and mobility of Site contamination, however, overall volume would increase with addition of treatment reagents. Some material toxicity would remain however, this material would have been stabilized and further isolated from the environment by a soil cover.

5.5.5 Short-Term Effectiveness

Short-term effectiveness of Alternative 5 would be dependent on the measures taken to reduce human and ecological exposure during remedial activities. Applicable regulations governing fugitive dust emissions would be followed during all Site activities. The remedial process would be designed to reduce exposures to human health and the environment.

5.5.5 Implementability

Remedial activities in this alternative include standard soil excavation, grading, hauling, backfilling and compaction techniques. All of the proposed activities include, but are not limited to, excavation, transportation, grubbing, grading and revegetation can be provided by local contractors. Site workers would be trained in hazardous material handling procedures. Local contractors are available to provide this service. The stabilization of contaminated materials would be more difficult to implement, however stabilization is a well established technology. Waste characterization and treatability studies would have to be conducted prior to full-scale implementation. United Park has stockpiled sufficient amounts of clean, low-permeability cover soil onsite.

5.5.6 Cost

The estimated costs for Alternative 5 as detailed in Table 5-7 are $ 144,708,705.72. The proposed costs include fifteen (15) years of operation and maintenance (O&M) costs.

6.0 SELECTION OF THE PREFERRED ALTERNATIVE

This section provides a comparison and ranking of the five alternatives detailed in Section 5.0 and selects the preferred alternative for the Site for recommendation to the public in the Proposed Plan. The preferred alternative for the Site is further detailed in this section.

6.1 Comparison and Ranking of Alternatives

This section compares the five alternatives and selects a preferred alternative. The five alternatives are described in detail in Section 5.0 and compared in this section are:

- Alternative 1 – No Action
- Alternative 2 – Soil Cover, Institutional Controls and Wedge Buttress

- Alternative 3 - Source Removal, Soil Cover and Wedge Buttress
- Alternative 4 – Excavation, Treatment and Offsite Disposal
- Alternative 5 – Excavation, Treatment and Onsite Disposal

Table 6-1 compares and ranks each of the alternatives based on the seven threshold and balancing criteria specified by the NCP.

6.1.1 Overall Protection of Human Health and the Environment

Alternative 1 does not provide an increase in human health or environmental protection at the Site. However, areas of the Site that do not pose a human health risk based on the BHHRA, such as areas of the impoundment covered by sufficient quantities of clean cover soil, do not appear to require remedial action at this time. Alternative 2 provides substantially more protection to human health and a moderate improvement in environmental protection; however, all of the contamination is left in place at the Site. Alternative 3 provides a higher degree of protectiveness to human health and the environment by removing contaminated materials from outside of the impoundment area and placing them inside the geometrically confined impoundment prior to the remediation of the impoundment area. Specified source areas would be removed, reducing the potential for water to come into contact with contaminated material. Alternative 4 provides the greatest degree of human and environmental health by removing the contaminated material from the Site. Alternative 5 provides a high degree of human and environmental health by stabilizing the waste and disposing of it onsite, however unlike Alternative 4 the treated waste remains onsite.

6.1.2 Compliance with ARARs

Alternative 1 takes no action to remediate contaminated soil or water at the Site and therefore may not comply with chemical specific ARARs. Action specific ARARs do not apply to Alternative 1 since no actions are taken.

Alternative 2 complies with ARARs but does not remove contamination from any Site locations.

Alternative 3 complies with ARARs and removes some of the source contamination areas but does remove contamination from the Site as a whole.

Alternatives 4 and 5 comply with ARARs.

6.1.3 Long-Term Effectiveness and Permanence

Alternative 1 does not change human health or environmental conditions at the site. The effectiveness of Alternatives 2 and 3 are dependent on the integrity and effectiveness of the soil cover and institutional controls, however Alternative 3 removes potential sources of contamination and places the material in a central geometrically confined impoundment area and hence is more effective than Alternative 2. Alternatives 4 and 5 are the most permanent solution since all contaminated material is stabilized the difference is in the disposal options. The treated waste remains onsite in Alternative 4 and is removed from the Site in Alternative 5 and hence no monitoring or maintenance is required.

6.1.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 1, 2 and 3 do not provide for any treatment of contaminated materials and do not comply with the statutory preference for treatment. Alternatives 4 and 5 provide for treatment of all materials that classify as hazardous waste. Alternative 2 reduces the mobility of the material by isolating it from the environment with a soil cover. Alternative 3 reduces the mobility of the material by removing certain source areas and placing the material in the geometrically confined impoundment area. The volume of material increases in Alternatives 4 and 5 due to the stabilization process, however the toxicity is reduced.

6.1.5 Short-Term Effectiveness

Alternative 1 has the least amount of short-term impacts because there is no remedial action and hence no short-term impacts to Site workers, the environment and nearby recreational users. Of the three alternatives that contain remediation activities Alternative 2 generates the least amount of traffic, dust and exposure to Site workers since waste is not transported. Alternative 3 transports contaminated materials onsite and contains the potential to expose Site workers to contaminated materials. Alternatives 4 and 5 transports and treats contaminated materials onsite therefore increasing the exposure potential. Offsite transportation of over 10,000 truckloads of material in Alternative 4 would increase local traffic.

6.1.6 Implementability

The simplest and easiest alternative to implement is Alternative 1 since there is nothing to implement. Alternative 2 is the second simplest and easiest alternative to technically implement since all equipment is available locally and soil for the soil cover has been stockpiled onsite. However, Of the three alternatives that propose remedial activity Alternative 2 is the only one that does not remove any source areas, due to this it might be difficult to implement administratively. Alternative 3 would be more difficult to implement than Alternative 2 since contaminated material would be transported onsite. However Alternative 3 would be easier to administratively implement since the major source areas would be removed and most of the contaminated material would be condensed into one location in a geometrically confined impoundment. Alternative 5 is more difficult to implement than Alternatives 1 through 3 since treatment and onsite disposal must be coordinated while minimizing short-term effects. Alternative 4 is technically the most difficult alternative to implement due to the largest amount of steps and components and the logistics of implementing the steps into an efficient cohesive package while minimizing short-term effects.

6.1.7 Cost

The estimated costs for each alternative are summarized below:

Alternative 1 – No Action	$ 0.00 (by definition)
Alternative 2 – Soil Cover, Institutional Controls and Wedge Buttress	$ 2,295,397.99

Alternative 3 - Soil Cover, Institutional Controls Source Removal and Wedge Buttress	$ 4,262,729.65
Alternative 4 – Excavation, Treatment and Offsite Disposal	$ 343,234,057.85
Alternative 5 – Excavation, Treatment and Onsite Disposal	$ 144,708,705.72

The estimated costs presented above are based on the information presented in this FS and are intended to be used as a comparative estimate within a range of +/- 50 %. Actual costs would be further refined during the remedial design for the Site.

6.2 Selection of Preferred Alternative

Table 6.1 uses a numeric ranking system to evaluate the advantages/disadvantages of each alternative. Each of the seven criteria are subdivided into sub-criteria. The sub-criteria are each assigned a ranking weight based on the overall importance to the project. This ranking weight allows each criteria's ranking to contribute to the total score based on their relative importance. For example, the overall protectiveness of human health and the environment has been assigned a ranking weight of 10 on a scale of 1 to 10. This can be compared to the ranking weight of 3 assigned to the availability of services and capacities which is relatively insignificant when compared to the overall protectiveness of human health and the environment which has a ranking weight of 10. With the exception of environmental impacts, short term effectiveness criteria have been assigned relatively low ranking weights due to their temporary nature. The assigned ranking weights are also Site-specific, for example community protection at the Site has been assigned a low weight due to the isolation of the Site, if the Site was located in an urban area the ranking weight would have been significantly greater.

The sub-criteria for each alternative are ranked on a scale of 1 through 5, with 1 signifying the least compliance and 5 signifying the greatest compliance. The sub-criteria's alternative rank are then multiplied by the ranking weight for the sub criteria to obtain a factored rank. The factored ranks were then totaled to obtain a total ranking for each alternative with the greatest total of points signifying the optimal choice. Costs were examined separately.

Ranking totals with costs excluded indicate that Alternatives 4 and 5 are significantly more advantageous than the other alternatives, however the costs of Alternatives 4 and 5 are significantly high enough to make these alternative cost-prohibitive. This is due to the fact that they are based on cost prohibitive treatment and disposal options. Based on the combination of ranking and costs, Alternative 3 presents the best combination of ranking and costs.

Based on the comparison of the five alternatives presented in Section 6.1 and the ranking and costs presented in Table 6-1, the preferred alternative is Alternative 3 – Soil Cover, Source Removal, Institutional Controls and Wedge Buttress. This alternative is protective of both human health and the environment, removes the source areas and is cost effective. While Alternatives 4 and 5 have the potential to be more protective of the environment by removing and treating contaminated material from the Site, Alternative 3 sufficiently protects the environment by immobilizing contamination within the geometrically confined impoundment. Alternative 3 is substantially more cost efficient than Alternatives 4 and 5.

6.3 Detailed Description of the Preferred Alternative

This Section presents and details the components and logistics for completing the preferred alternative.

6.3.1 Preferred Alternative Preliminary Design Components

The selected remedial alternative entails the following steps/design components:

- Removal of contaminated materials in selected areas south of the diversion ditch and at a later time in the wetland below the main embankment. This step would include overexcavation of the contaminated material by six-inches (6") or the depth required to remove all traces of contamination if six-inches (6") is not sufficient. Excavation would be guided by field personnel using a portable X-ray fluorescence meter. Confirmation samples would be submitted to a laboratory using methodologies detailed in the SAP (RMC, 2001).
- Relocating the excavated materials to the low-lying northerly area within the impoundment;

- Placement of a twelve (12) inch thick low permeability soil cover on areas where tailings are left in-place including the impoundment. The cover would be placed in six-inch lifts and compacted. Upon completion of the impermeable soil cover, a final six (6) inch topsoil cover would be placed. The final surface would be graded to control surface stormwater runoff and drainage. Drainage swales and runoff channels may be installed where required to direct surface runoff toward the diversion ditch. Where applicable stormwater runoff control structures would be constructed using erosion resistant materials such as geotextile fabric and rip-rap.
- Placement of twelve (12) inches of clean gravel over contaminated sediments in the diversion ditch.
- Installation of a wedge buttress along the oversteepened portion of the embankment (for about 400 feet of the total embankment length of 800 feet). A preliminary design for the wedge buttress was prepared by AGEC for United Park in October 2001. Based on existing information from previous studies AGEC determined that there would be a 50% increase in stability if a buttress fill was placed along the toe of the embankment with the height of the fill approximately 10 feet above the toe and extending horizontally out from the embankment face approximately 30 feet. A similar increase would be obtained by modifying the fill height to 15 feet and the horizontal width to 20 feet. Prior to construction, the upper soil and existing vegetation and organic matter would be removed prior to fill placement. Drain material and possibly a filter blanket (if required) would be placed prior to the buttress fill. Seep water currently emanating from the embankment would be diverted to the South Diversion Ditch. The buttress fill material would be compacted to at least ninety-five (95) percent of the maximum dry density as determined by ASTM D-698 at a moisture content within two (2) percent of optimum. At the end of construction the buttress fill would be protected from erosion by vegetation or other methods.
- Regrading and revegetation of areas affected by remedial activities at the Site. Areas in which tailings were removed would be restored, where possible, to existing topographic conditions; and
- Monitoring Site conditions on a periodic basis for 5 years.

Remedial areas are presented in Figure 5-2.

6.3.2 Preferred Alternative Volume Estimation

As previously discussed in Table 5-3 and Section 5.3. the estimated volumes of contaminated materials to be removed in the design and cost estimates are as follows:

Tailings South of the Diversion Ditch* 178,266 yd^3

* - This volume include six (6) inches of underlying and existing cover materials.

Contaminated Sediment in the Wetland* 10,365 yd^3

* - This volume represents the removal of one (1) foot of sediments.

6.3.3 Preferred Alternative Costs

As previously discussed in Table 5-5 and Section 5.3 **the estimated cost for the preferred alternative is $ 4,262,729.65**. This cost is based on the information presented in this FS and is intended to be used as a comparative estimate within a range of +/- 50 %. Actual costs will be further refined during the remedial design for the Site.

7.0 REFERENCES

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Dames & Moore, 1974, Report of Embankment and Dike Design Requirements, Proposed Tailings Pond Development, Near Park City, Utah: Consultant's report prepared for Park City Ventures Corporation, March, 1974.

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Resource Management Consultants, Inc (RMC), 2004, Draft Focused Remedial Investigation Report for Richardson Flat, Site ID Number: UT980952840.

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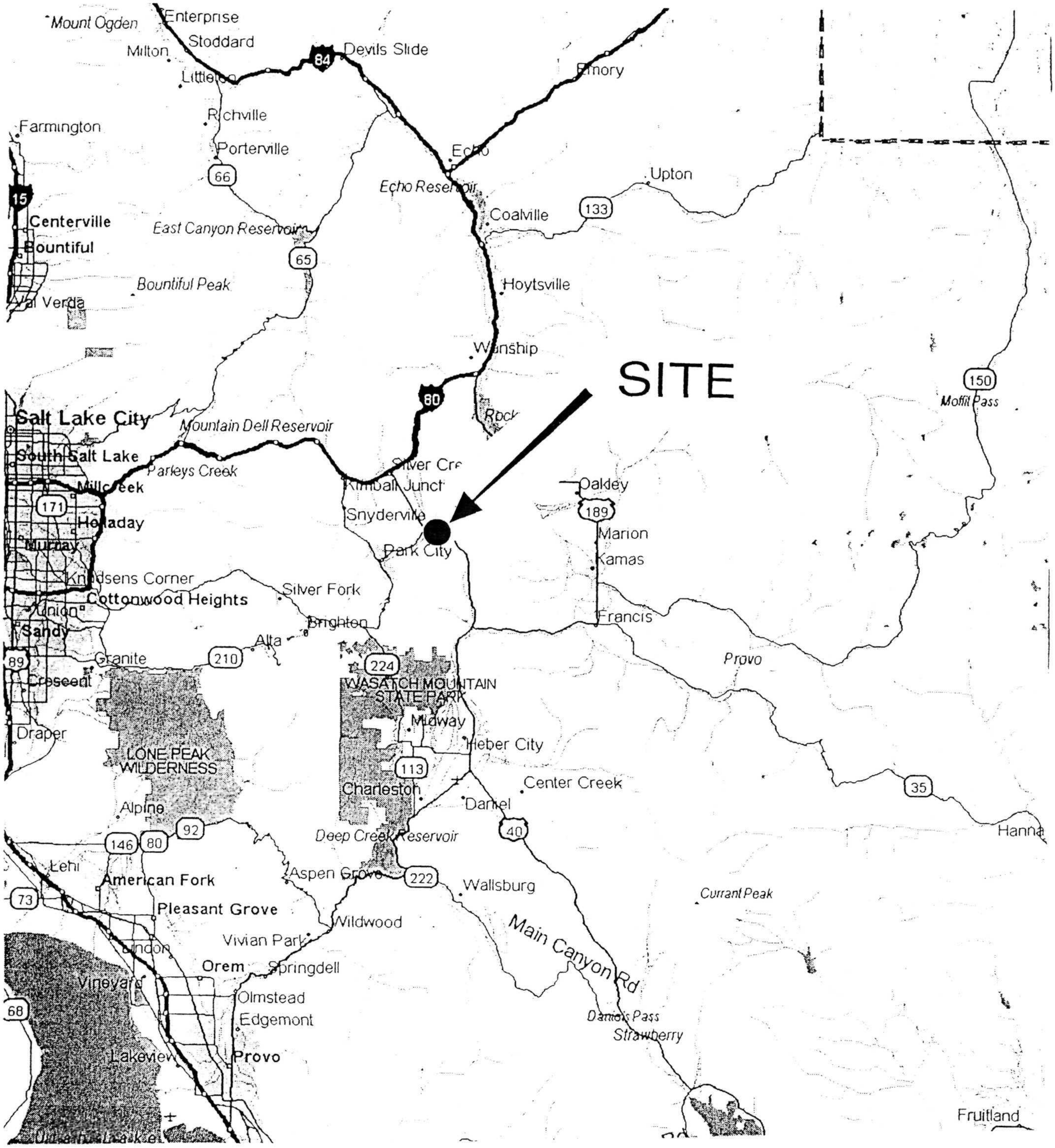
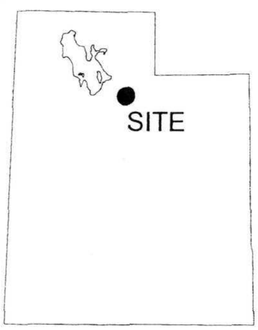
Weston Engineering Inc., 1999, Preliminary Hydrogeologic Review of Richardson Flats Tailing Site, Prepared for LeBoeuf, Lamb, Greene & MacRae, LLP, March 23, 1999.

List of Figures





NOT TO SCALE

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FIGURE 1-1
SITE LOCATION MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

MAY 2004

ri-site-location-map-dwg

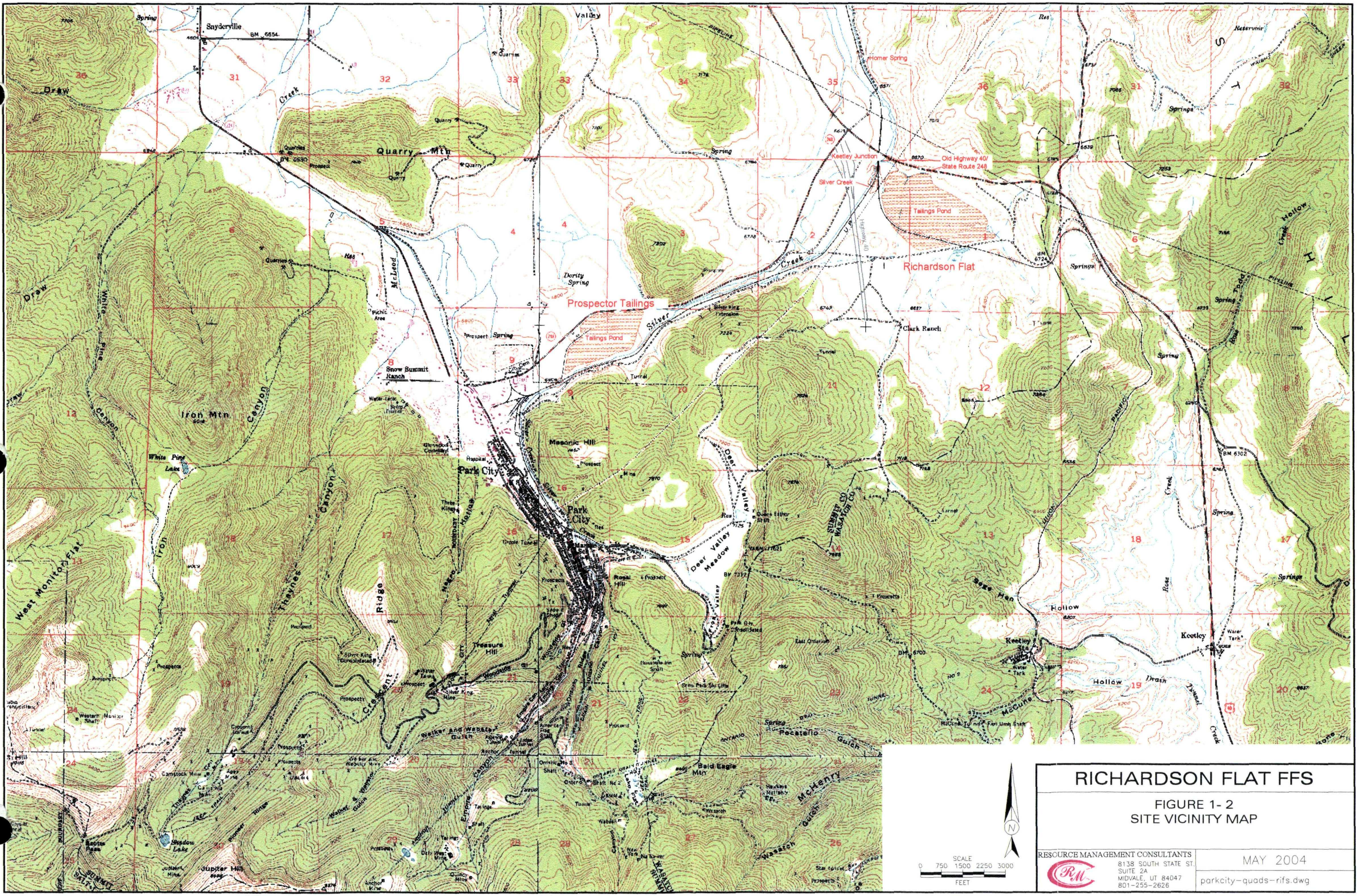

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FIGURE 1- 2
SITE VICINITY MAP

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parkcity-quads-rifs.dwg

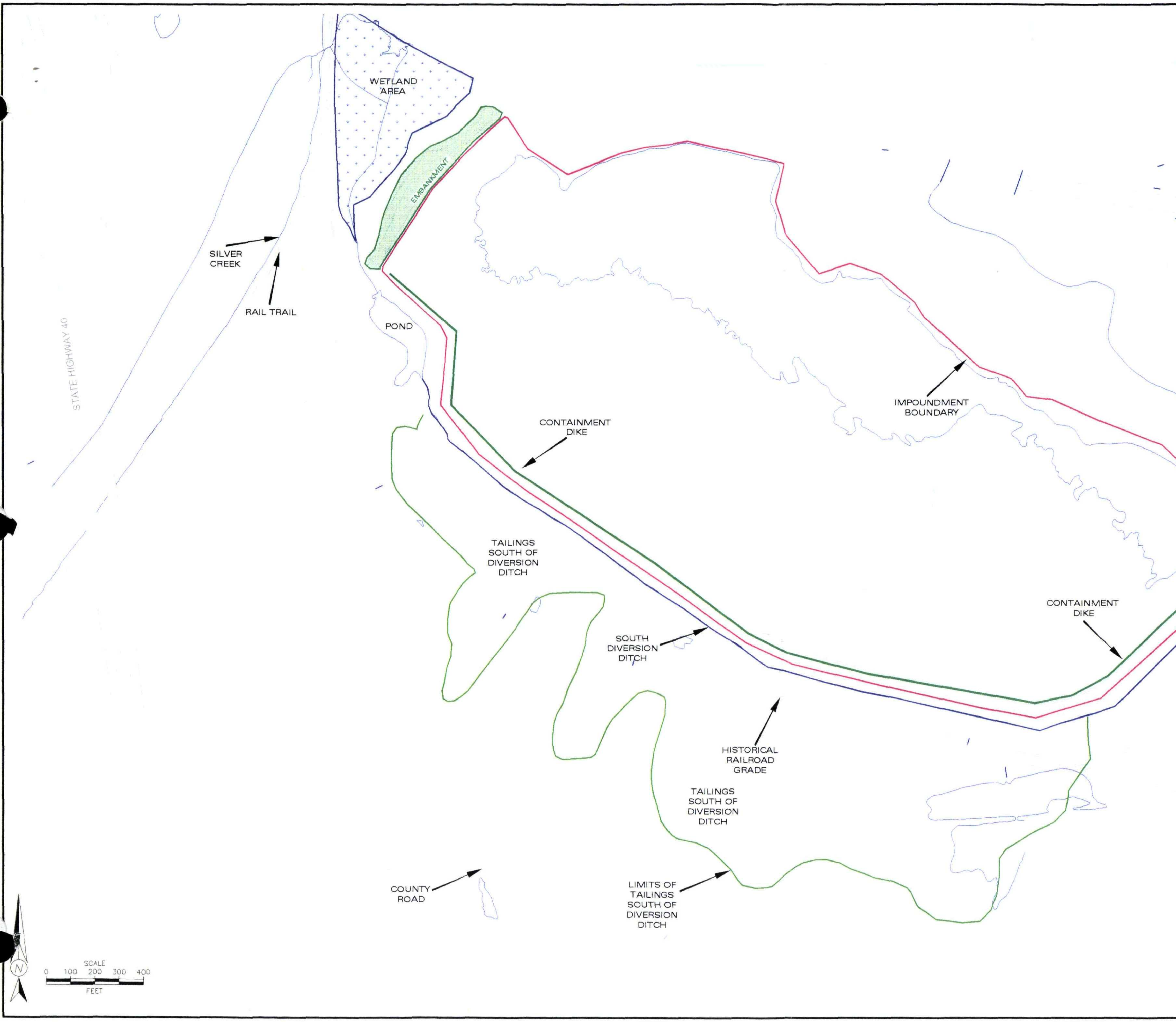

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FIGURE 1-3
SITE FEATURES

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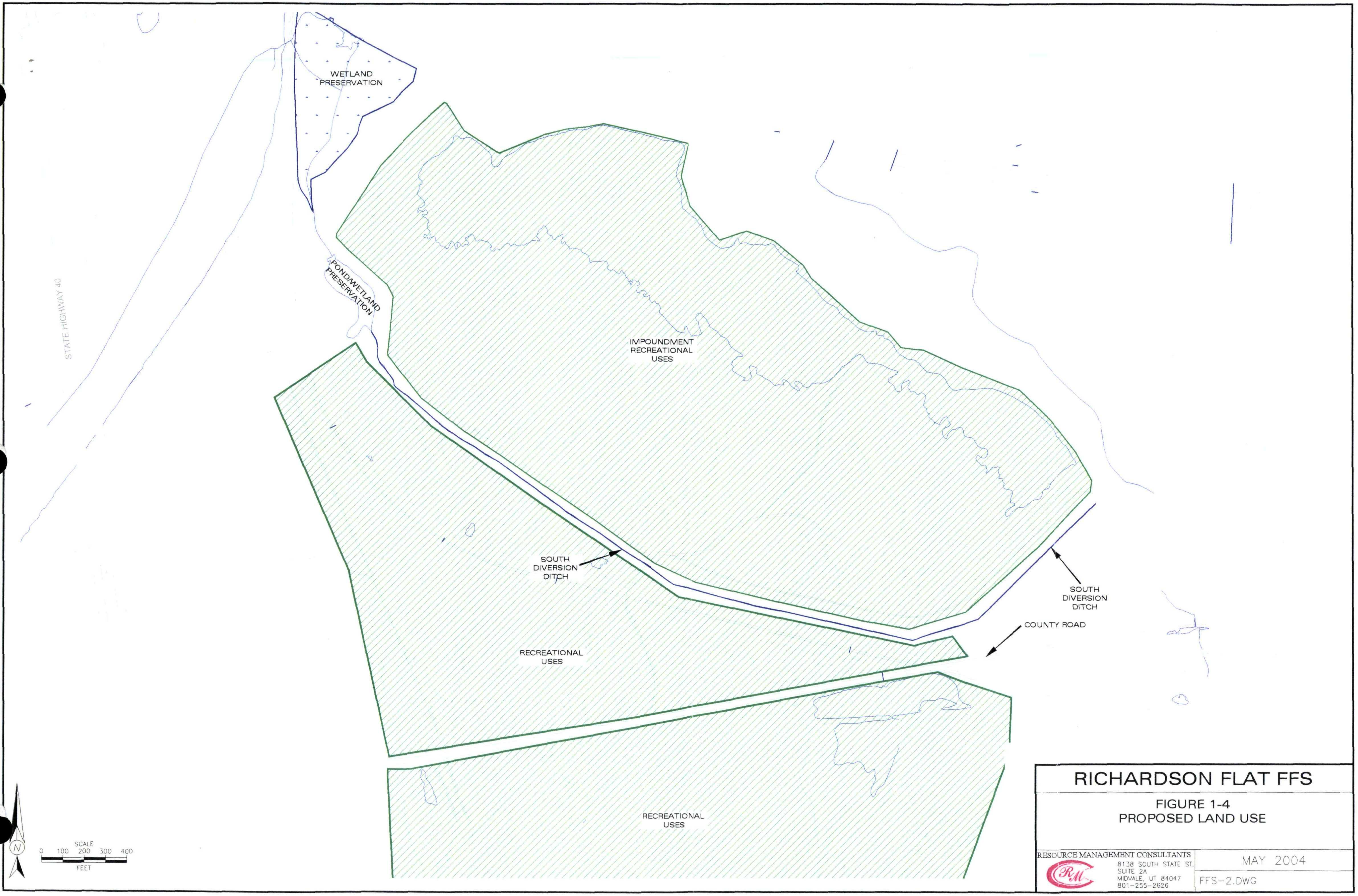

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FIGURE 1-4
PROPOSED LAND USE

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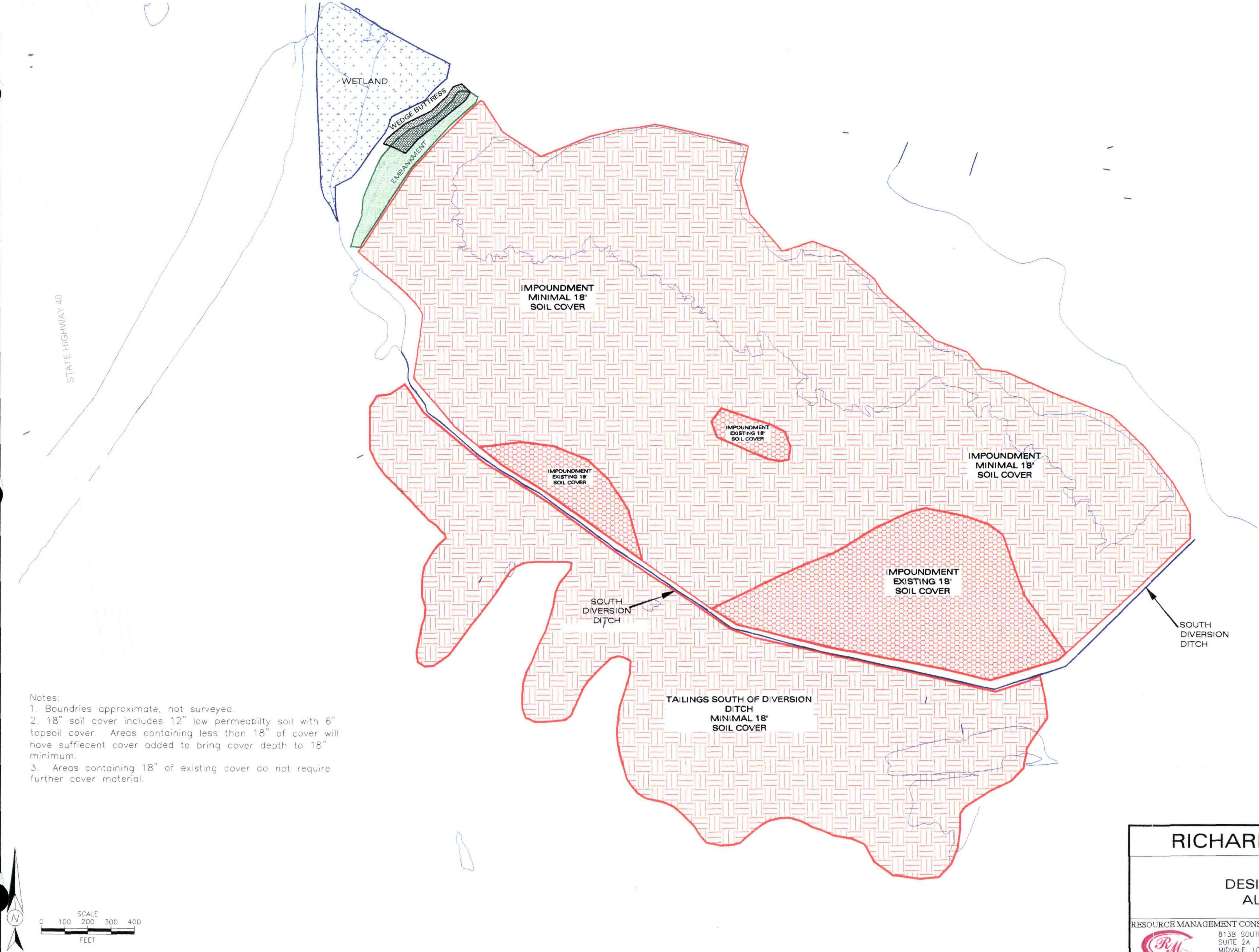

Notes:
1. Boundries approximate, not surveyed.
2. 18" soil cover includes 12" low permeabilty soil with 6" topsoil cover. Areas containing less than 18" of cover will have suffiecent cover added to bring cover depth to 18" minimum.
3. Areas containing 18" of existing cover do not require further cover material.

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FIGURE 5-1
DESIGN SCHEMATIC
ALTERNATIVE 2

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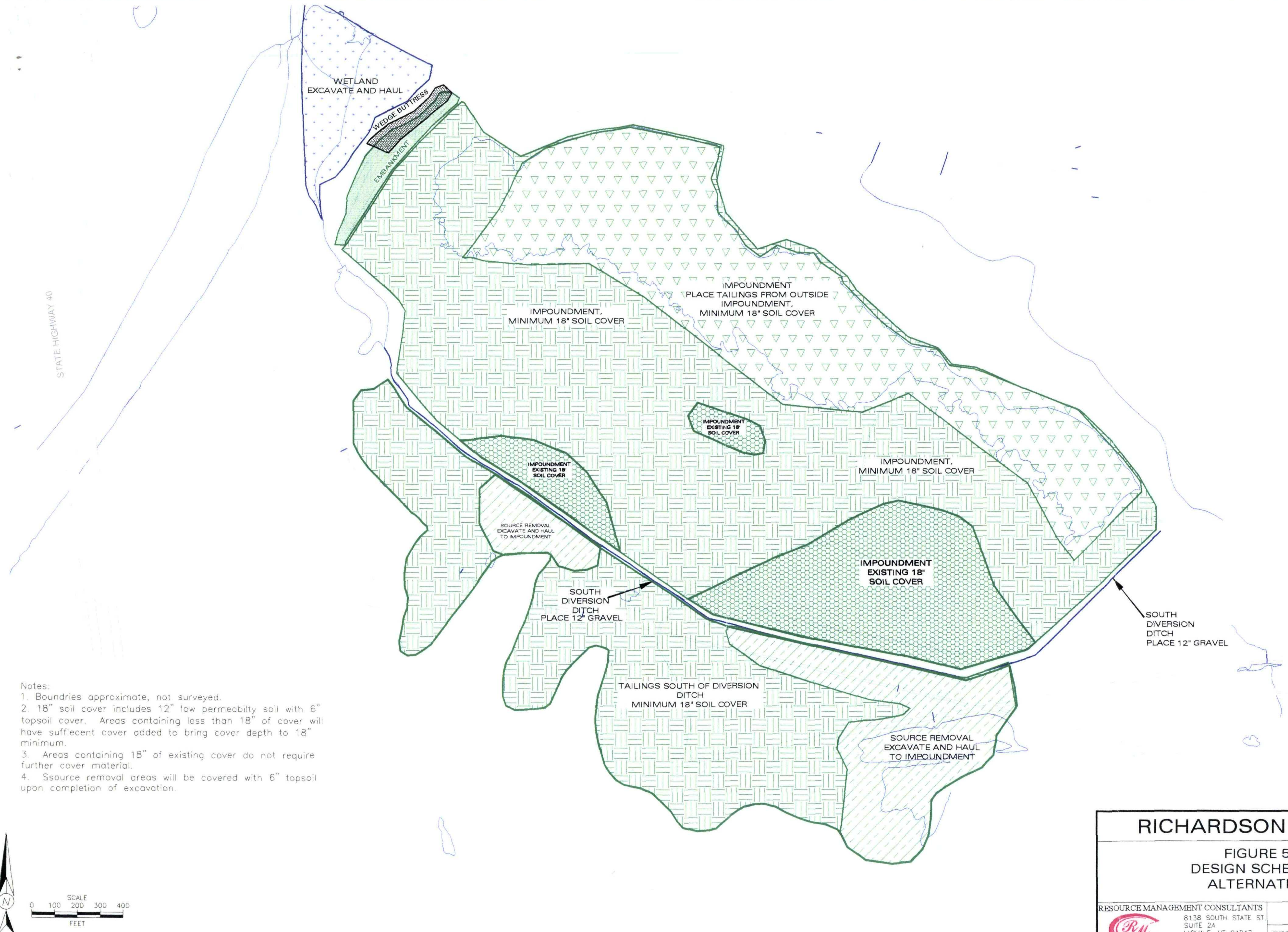

Notes:
1. Boundries approximate, not surveyed.
2. 18" soil cover includes 12" low permeabilty soil with 6" topsoil cover. Areas containing less than 18" of cover will have suffecent cover added to bring cover depth to 18" minimum.
3. Areas containing 18" of existing cover do not require further cover material.
4. Ssource removal areas will be covered with 6" topsoil upon completion of excavation.

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FIGURE 5-2
DESIGN SCHEMATIC
ALTERNATIVE 3

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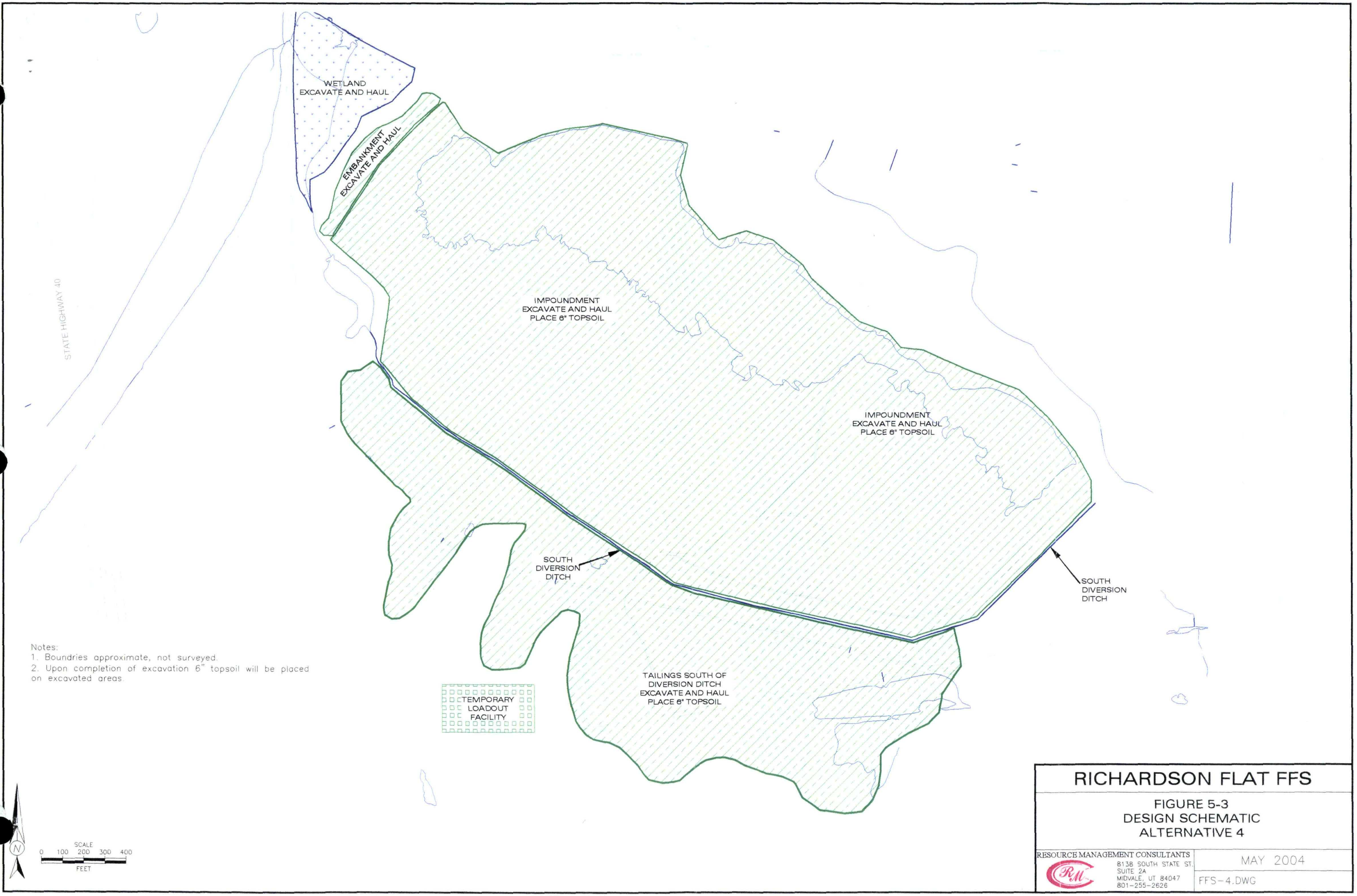

Notes:
1. Boundries approximate, not surveyed.
2. Upon completion of excavation 6" topsoil will be placed on excavated areas.

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FIGURE 5-3
DESIGN SCHEMATIC
ALTERNATIVE 4

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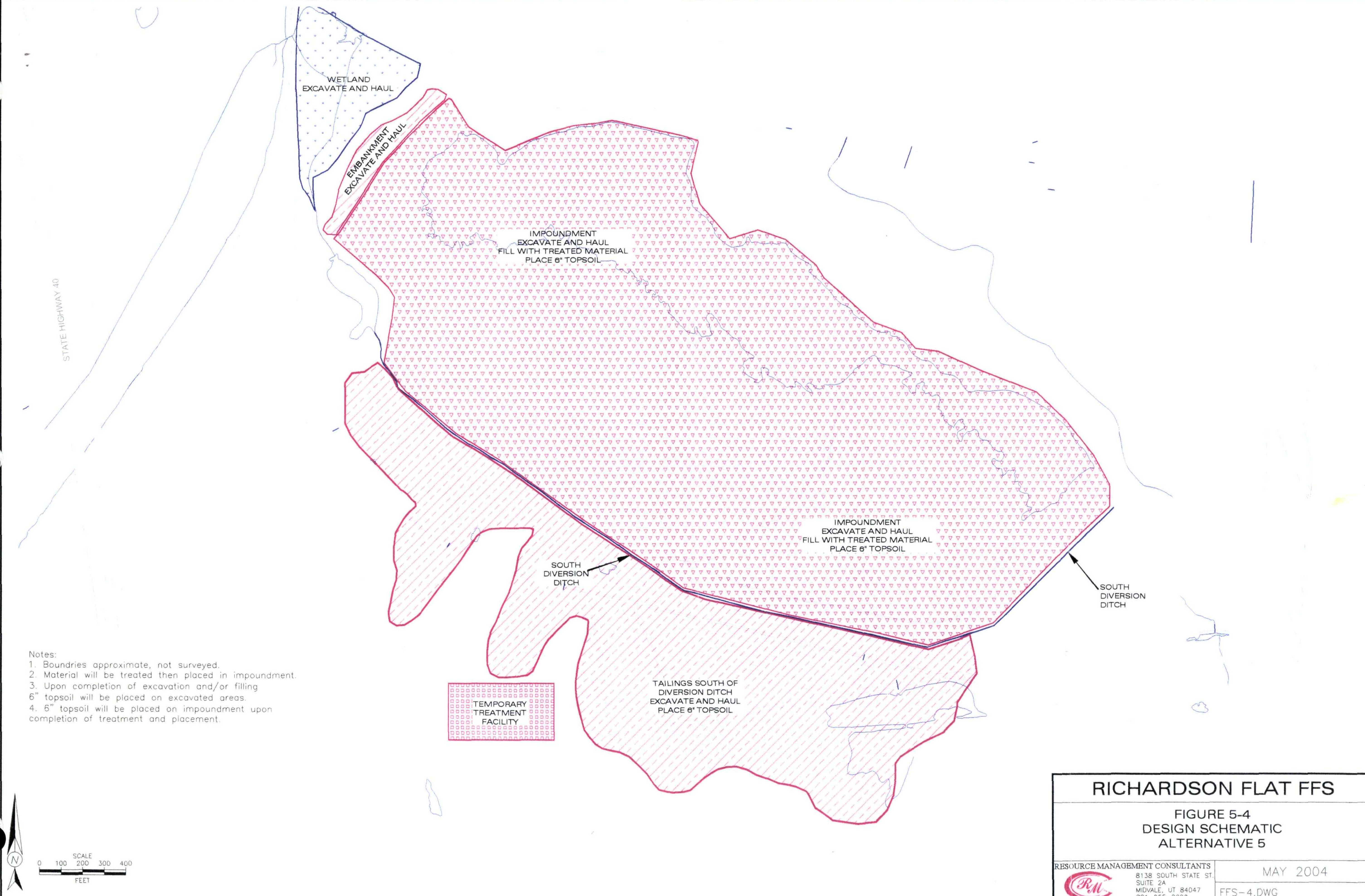

Notes:
1. Boundries approximate, not surveyed.
2. Material will be treated then placed in impoundment.
3. Upon completion of excavation and/or filling 6" topsoil will be placed on excavated areas.
4. 6" topsoil will be placed on impoundment upon completion of treatment and placement.

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FIGURE 5-4
DESIGN SCHEMATIC
ALTERNATIVE 5

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List of Tables

Table 2-1
Chemical Specific ARARs

Requirement	Citation	Description	Determination	Comment
Definitions and General Requirements of Utah Water Quality Act	UAC R317-1	Provides definitions and general requirements for waste discharges to waters of the State of Utah	Applicable	Substantive standards are applicable to point source discharges of contaminants into Silver Creek (if any), but permitting requirements would be preempted by operation of 42 USC 9621(e)(1).
Utah Surface Water Quality Standards	UAC R317-2-6 UAC R317-2-13 UAC R317-2-14	Establishes use designations for Silver Creek (as tributary to the Weber River): Class 1C - Protected for domestic purposes with prior treatment processes as required by Utah Div. of Drinking Water. Class 2B - Protected for secondary contact recreation such as boating, wading. Class 3A - Protected for cold water species of game fish and aquatic life. Class 4 - Protected for agricultural uses and stock watering	Applicable	Substantive standards are applicable to point source discharges of contaminants into Silver Creek (if any), but permitting requirements would be preempted by operation of 42 USC 9621(e)(1).
Groundwater Quality	UAC R317-6	Establishes state groundwater quality standards	Applicable	Substantive standards are applicable to discharges of contaminants to ground water discharges (if any), but permitting requirements would be preempted by 42 USC 9621(e)(1).
Solid and Hazardous Waste	40 CFR § 261.4(b)(7)	Criteria for the Identification and Listing of Hazardous Waste	Applicable	Mine tailings are not a hazardous waste.
Solid and Hazardous Waste	UAC R311-211-3	Corrective Action Cleanup Standards Policy -UST and CERCLA sites	Applicable	RPM will establish appropriate cleanup standards based on the factors set forth in R311-211-3.
Utah Storm Water Rules	UAC R317-8-3.9	Establishes state storm water requirements	Applicable	Requires implementation of best management practices to address storm water management at the Site.

Table 2-1 (continued)
Location Specific ARARs

Requirement	Citation	Description	Determination	Comment
Protection of Wetlands	33 USC § 1344	Prohibits discharge of dredged or fill materials into waters of the United States.	Relevant and Appropriate	Although 404 permit is not required, the remedy should seek to avoid, restore, or mitigate impacts to jurisdictional wetlands as appropriate.
Historic Sites, Building and Antiquities Act	16 USC §§ 461-467	Requires protection of landmarks listed on National Registry	Applicable	Proposed activities will not adversely affect any listed landmark
National Historic Preservation	16 USC § 470	Requires protection of district, site, building, structure or object eligible for inclusion in national register of historic places	Applicable	Proposed activities will not adversely affect any such district, site, building, structure or object
Archeological and Historic Preservation Act	16 USC § 469	Requires preservation of significant historical and archeological data	Applicable	Proposed activities will not adversely affect archeological data or landmarks
Fish and Wildlife Coordination Act	16 USC § 662	Requires that actions taken in areas that may affect streams and rivers be undertaken in a manner that protects fish and wildlife	Applicable	USFWS has been consulted with regard to actions impacting Silver Creek
Endangered Species Act	16 USC § 1531	Requires protection of endangered and threatened species	Applicable	USFWS has been consulted with regard to protection of endangered and threatened species.
Migratory Bird Treaty Act	16 USC § 703 *et seq*	Requires protection of migratory nongame birds	Applicable	USFWS has been consulted with regard to protection of migratory nongame birds.
RCRA Subtitle D Solid Waste Requirements	UAC R315-303-3(4)	Establishes closure requirements for permitted solid waste landfills.	Relevant/Appropriate	Relevant and appropriate to onsite repository under Alternatives 3 and 5, to the extent technically practicable.
Air Quality	UAC R307-205-6	Emission Standards	Applicable	Requires management practices to limit fugitive emissions from tailings piles.

Table 2-1 (continued)
Action Specific ARARs

Requirement	Citation	Description	Determination	Comment
Abandoned wells	UAC R655-4	Standards for drilling and abandonment of wells.	Applicable	Applicable to the drilling or closing of wells that are abandoned or installed as part of the remedy.
Utah Storm Water Rules	UAC R317-8-3.9	Establishes state storm water requirements	Applicable	Requires implementation of best management practices to address storm water management at the Site.
Criteria for Classification of Solid Waste and Disposal Facilities and Practices	40 CFR Part 257.3	Establishes Criteria for use in determining which solid waste facilities and practices could adversely affect human health and the environment	Applicable	
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes Standards for Generators of Hazardous Waste	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.
General Facilities Standards	UAC R315-8-2	Location Standards	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.
Closure and Post Closure	UAC R315-8-6	Closure Plan/Performance Standards	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.

Table 2-1 (continued)
Action Specific ARARs

Waste Piles	UAC R315-8-12	Waste piles performance standards	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.
Landfills	UAC R315-8-14	Performance standards for landfills	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.
Risk Based Closure Standards	UAC R315-101	Establishes risk-based closure and corrective action standards	Applicable	Applicable to any hazardous waste that is not Bevill-exempt.
Corrective Action Cleanup Standards Policy	UAC R311-211	Lists general criteria in Establishing clean up standards	Applicable	RPM will establish appropriate cleanup standards based on the factors set forth in R311-211-3.
OSHA	29 USC § 651	Regulates workers health and safety	Applicable	
Utah Ground Water Quality Protection Rules	UAC R317-6	Contaminants that remain on site must not present a leaching threat to ground water	Applicable	Substantive standards are applicable to discharges of contaminants to ground water discharges (if any), but permitting requirements would be preempted by 42 USC 9621(e)(1)
Standards Applicable to Hazardous Waste Transporters	40 CFR Part 263	Regulates Transportation of Hazardous Waste	Applicable	Relevant and appropriate to any hazardous waste that is not Bevill-exempt.

Table 4-1
Initial Screening of Remedial Technologies

Technology	Effectiveness	Implementability		Costs		Retained for Detailed Analysis	Comments
		Technical	Administrative	Capital	O & M		
Soil cover	Low	Easy	Difficult	Low	High	Yes	Place soil cover over contaminated material, has been used extensively for tailings impoundments.
Soil cap	Low	Easy	Difficult	High	High	No	Additional protection by geomembrane not warranted for site, reuse of site impaired by geomembrane.
Excavation and removal [a]	High	Moderate	Moderate	High	Low	Yes	Is not effective as stand alone must be combined with treatment and disposal technologies.
In-situ chemical stabilization	Medium	Very Difficult	Difficult	High	Medium	No	Material will be treated in-place. Very difficult to implement due to depth of contaminated material.
Reclamation and revegatation	Low	Easy	Easy	Low	Medium	Yes	Not a stand alone technology. Retained in combination with other technologies.
Soil washing [a b]	High	Moderate	Easy	High	Low	No	Can be combined with chemical separation for soil reuse
Soil treatment (stabilization) [a b]	High	Moderate	Easy	High	Low	Yes	Soils will be treated to reduce mobility of contaminants. Some soils may not be treatable.
Surface and groundwater treatment	Low	Moderate	Easy	High	High	No	Due to low levels of contamination not an effective remedy. Source control is anticipated and will be more effective than treatment

Notes.
Two scales: Low, Medium, High and Easy, Moderate, Difficult, Very Difficult.
a- See table 4-2 for disposal options.
b- Includes excavation prior to use of listed technology.
O&M - Operation and maintenance

Table 4-2
Initial Screening of Soil Disposal Options

Technology	Effectiveness	Implementability		Costs	Retained for Detailed Analysis	Comments
		Technical	Administrative			
Placement of untreated materials in impoundment[a]	Low	Easy	Moderate	Low	Yes	Material from outside the impoundment area will be placed with like and similar wastes in the impoundment.
Treatment and disposal in new single use landfill[b]	High	Difficult	Difficult	High	Yes	Material will be treated and disposed of onsite in impoundment area.
Treatment and Offsite Disposal in Class IV C&D Landfill[c]	High	Difficult	Moderate	High	Yes	Soils not treatable will have to go to Subtitle C landfill.
Offsite Disposal in RCRA Subtitle C Landfill[d]	High	Moderate	Easy	High	No	Cost prohibitive due to large amount of material. Maybe required if treated waste fails TCLP.

Notes:

2 scales: Low, Medium, High and Easy, Moderate, Difficult, Very Difficult.

a - Currently existing impoundment

b- Located in location of current impoundment

c- Class IV landfill - East Carbon Development Corp., Carbon County, Utah

d- Subtitle C landfill - Safety-Kleen Grassy Mountain landfill, Tooele County, Utah

C&D- Construction and demolition

RCRA- Resource Conservation and Rrecovery Act

Table 5-1
Summary of Remedial Alternatives

Alternative 1 – No Action

- No action alternative is required by CERCLA and NCP.
- No action will be taken to address Site contamination.

Alternative 2 – Soil Cover with Institutional Controls and Wedge Buttress

- Placing 238,560 cyds of clean soil to achieve an 18" soil cover over the entire Site.
- Institutional controls will be designed and implemented to limit human contact with contaminated material.
- Soil cover will be graded to direct stormwater and surface runoff off the impoundment.
- Soil cover will prevent the infiltration of surface water into the ground on and off the impoundment.
- Soil cover will be revegetated.
- South Diversion Ditch and wetland areas will be preserved.
- Install wedge buttress to increase the stability of the embankment.

Alternative 3 – Source Removal, Soil/Gravel Cover and Wedge Buttress

- 115,866 cyds of tailings from the tailings south of the diversion ditch will be excavated and placed on the impoundment.
- 283,625 cyds of clean soil will be placed as a soil cover on and off the impoundment to achieve 18" of soil cover.
- Areas where tailings were removed will be regraded to preexisting topography, where possible and revegetated.
- Soil cover will be graded to direct stormwater and surface runoff away from contaminated material.
- Excavated areas will be covered with a 6-inch layer of topsoil.
- The soil cover will be revegetated.
- Place 956 cyds of gravel in the South Diversion Ditch to achieve 12" cover on sediments.
- Excavate and haul wetland sediments to impoundment.
- Install wedge buttress to increase the stability of the embankment.
- Implementing institutional controls for any contaminant left in place.

Table 5-1
Summary of Remedial Alternatives

Alternative 4 – Excavation, Treatment and Offsite Disposal

- Excavating 2,980,988 cyds of material from the impoundment, floodplain tailings, tailings south of the diversion ditch, and wetlands.
- Stabilizing excavated material at an onsite temporary treatment facility with flyash or portland cement to achieve LDRs of 5 ppm extractable lead and 5 ppm AS (using TCLP) where possible.
- Transporting material to a C&D (Class IV) or Subtitle C landfill, depending on the results of waste classification (using TCLP).
- Excavated areas will be covered with a 6-inch layer of topsoil.
- Regrade and revegetate all excavated areas.
- South Diversion Ditch and wetlands areas will be remediated and reconstructed.
- Implementing institutional controls for any contaminant left in place.
- Remove embankment when all materials are removed from impoundment.

Alternative 5 – Excavation, Treatment and Onsite Disposal

- Excavating 2,980,988 cyds of material from the impoundment, floodplain tailings, tailings south of the diversion ditch and wetlands.
- Stabilizing excavated material at an onsite temporary treatment facility with flyash or portland cement to achieve LDRs of 5 ppm extractable lead and 5 ppm AS (using TCLP) where possible.
- Placing material in temporay onsite repository until space is available to construct permanent onsite repository.
- Repository will be covered with a 12 inch layer of clean, low permeability soil and a 6-inch layer of topsoil.
- Regrade and revegetate all excavated areas and repository.
- South Diversion Ditch and wetlands areas will be remediated and reconstructed.
- Implementing institutional controls for any contaminant left in place.
- Remove embankment when all materials are removed from impoundment.

Table 5-2
Comparative Analysis of Final Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Soil Cover/Institutional Controls and Wedge Buttress	Alternative 3 Soil Cover/Source Removal and Wedge Buttress	Alternative 4 Excavation, treatment and Offsite Disposal	Alternative 5 Excavation, Treatment and Onsite Disposal
OVERALL PROTECTIVENESS					
Human Health- Direct contact and inhalation.	Based on results of BHHRA human health exposures at the Site are within acceptable limits.	The cover reduces direct contact, inhalation and ingestion of contaminated soil and meets human health requirements.	The cover reduces direct contact, inhalation and ingestion of contaminated soil and meets human health requirements. Potential for contact reduced by a reduction in extent of tailings. Some protection to areal environment by partial source removal.	Removal, treatment and offsite disposal of contaminated material reduces and eliminates the risk of direct contact, inhalation and ingestion of contaminated soil and meets human health requirements	Removal, treatment and onsite disposal of contaminated material reduces and potentially eliminates the risk of direct contact, inhalation and ingestion of contaminated soil and meets human health requirements
Environmental Protection	Site exposures remain. There is likely to be some attenuation over time in water.	The soil cover reduces some ecological risk and will help to reduce surface water infiltration into the contaminated material and hence will improve groundwater quality The source material stays in place	The soil cover reduces some ecological risk and will help to reduce surface water infiltration into the contaminated material. Most material will be located in the geometrically confined impoundment. Removal of groundwater and surfacewater contamination source areas will improve water quality	Site contamination is removed and the environmental quality of Site is improved.	Site contamination is treated and the environmental quality of Site is improved.
COMPLIANCE WITH ARARS					
Chemical-specific ARAR	Not satisfied	Environmental protection is met, however all contamination remains onsite.	Air quality protection is met, however all contamination remains onsite but is located in a centralized location in a closed impoundment. Surface water and groundwater quality is improved.	Air quality protection is met and all contamination is removed from the Site. Surface water and groundwater standards are met.	Air quality protection is met and contamination is treated onsite. Surface water and groundwater standards are met.
Location-specific ARAR	Not satisfied	Location-specific ARARs are met	Location-specific ARARs are met	Location-specific ARARs are met	Location-specific ARARs are met
Action-specific ARAR	Not applicable	Federal and State regulations will be met during remedial activities	Federal and State regulations will be met during remedial activities	Federal and State regulations will be met during remedial activities	Federal and State regulations will be met during remedial activities
Other criteria/guidance	Would allow contact, however human health risks are within acceptable limts.	protects against inhalation/direct contact.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of residual risk	Source not removed. Existing risk will remain.	Source not removed. Existing risk will be reduced by the soil cover.	Source is partially removed. Existing risk will remain but will be reduced as most materials will be placed in centralized location in a confined impoundment and covered. Surface water and groundwater quality is improved.	Contaminated materials are removed from the Site. No residual risk.	Contaminated materials are treated and left onsite. Magnitude of residual risk is significantly reduced. No residual risk
Adequacy and reliability of controls	No controls over remaining contamination. No reliability.	Soil cover integrity will be maintained by institutional controls and monitoring. Reliability will be maximized through cover design and enforcement of institutional controls.	Soil cover integrity will be maintained by institutional controls and monitoring. Reliability will be maximized through design and enforcement of institutional controls as well as placement of tailings in geometrically confined impoundment.	None required, contaminated material will be removed from Site.	Site and treated materials will be monitored to insure that Site is not affecting human health and the environment.
REDUCTION OF TOXICITY, MOBILITY OR VOLUME					
Treatment process used	None used	None used	None used	Stabilization/fixation	Stabilization/fixation
Amount destroyed or treated	None	None	None	2,847,087 cubic yards	2,847,087 cubic yards
Reduction of toxicity, mobility or volume treatment	None	Mobility is reduced by soil cover.	Mobility is reduced by moving most contaminated materials into the geometrically confined impoundment with a soil cover. Remaining materials will be covered.	Mobility is reduced by treatment and disposal in a regulated facility. Increase in volume with a decrease in toxicity.	Mobility is reduced by treatment. Increase in volume with a decrease in toxicity.
Statutory preference for treatment	Does not satisfy	Does not satisfy	Does not satisfy	Satisfied	Satisfied
SHORT TERM EFFECTIVENESS					
Community protection	Risk not increased by remedy implementation.	Risk not increased by remedy implementation	Risk not increased if action specific ARARs are met during remediation.	Risk not increased if action specific ARARs are met during remediation. Transportation may increase community risks due to increase in truck traffic.	Risk not increased if action specific ARARs are met during remediation.
Worker protection	No risk to workers	Risk is minimal since contaminated material is not being handled.	Workers will be handling contaminated material during onsite transport, contact with contaminated fugitive dust is possible during excavation and disposal.	Workers will be handling contaminated material during onsite transport and treatment, contact with contaminated fugitive dust is possible during excavation and disposal.	Workers will be handling contaminated material during onsite transport and treatment, contact with contaminated fugitive dust is possible during excavation and disposal.
Environmental impacts	Continued impact from existing conditions	Dust generated during remedial activities.	Dust generated during remedial activities.	Dust generated during remedial activities. Potential effects from ditch excavation.	Dust generated during remedial activities. Potential effects from ditch excavation.
Time until action is complete	N/A	One to two construction seasons.	One to two construction seasons.	One to two construction seasons.	One to two construction seasons.
IMPLEMENTABILITY					
Ability to construct and operate	No construction or operation required.	Standard excavation and transportation technologies are easily implemented. Standard institutional controls easily implemented. Cover soil is stockpiled onsite and available locally.	Standard excavation and transportation technologies are easily implemented. Remedial contractors are locally available. Cover soil is stockpiled onsite and available locally.	Standard excavation and transportation technologies are easily implemented. Remedial contractors are locally available. Cover soil is stockpiled onsite and available locally. Bench-scale testing will need be conducted. Treatment contractors and disposal facilities are available.	Standard excavation and transportation technologies are easily implemented. Remedial contractors are locally available. Cover soil is stockpiled onsite and available locally. Bench-scale testing will need be conducted. Treatment contractors and disposal facilities are available.
Ease of additional remediation, if needed	Easy, as no remediation has been done in this alternative.	Would impact original remedy.	Would impact original remedy.	Would impact original remedy.	Would impact original remedy.
Ability to monitor effectiveness	No monitoring required.	Periodic monitoring required.	Periodic monitoring required.	Periodic monitoring required until verification that site is not effecting human or environmental health.	Periodic monitoring required until verification that site is not effecting human or environmental health.
Ability to obtain approval from other agencies	Very difficult to obtain "no action" from agencies.	Difficult to obtain approval since ground water source contamination is left in place. High level of coordination with state and federal agencies will be required for long-term monitoring and compliance.	Less difficult than Alternative 2 since ground water source contamination is removed. Moderate level of coordination with state and federal agencies will be required for long-term monitoring and compliance.	Less difficult than Alternatives 2 and 3 since contamination is removed. Moderate level of coordination with state and federal agencies will be required for short-term monitoring and compliance. Agency coordination will be required for disposal.	More difficult than Alternatives 3 and 4 since contamination remains onsite. Moderate level of coordination with state and federal agencies will be required for short-term monitoring and compliance. Agency coordination will be required for disposal and site closure.
Availability of services and capacities	No services or capacities required.	No disposal required. All services available.	No disposal required. All services available.	Disposal types and capacities need to be determined, but should be available. Large scale transportation logistics will be required.	Final volumes need to be determined, but buildup of impoundment height should provide sufficient volume capacity.
Availability of technology	None required	Required technology available.	Required technology available.	Specialized treatment technology is required but available.	Specialized treatment technology is required but available.
COST					
Direct Capital Cost	$0	$1,849,281.00	$3,509,476.50	$289,561,230	$121,902,705.25
Indirect Costs (includes O&M)	$0	$446,116.99	$753,253	$53,672,828	$22,806,000
Total Cost	$0	$2,295,397.99	$4,262,729.65	$343,234,057.85	$144,708,705.72
STATE ACCEPTANCE	protective of human health and environment	Potentially Yes	Yes	Yes	Yes
COMMUNITY ACCEPTANCE	See Note A	See Note A	See Note A	See Note A	See Note A

Notes:
A - Will be evaluated during the CERCLA-required Public Comment period.
ARAR - Applicable or Relevant and Appropriate Requirement
O&M - Operations, maintenance and monitoring

Table 5-3
Richardson Flat Soil Volume Calculations

Wetland	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	Notes
wetland	279,852	1.0	279,852	10,365		Per foot of excavation.
place access (14' wide, 2000' total length)	28,000	3	84,000	3,111		Assume 14' wide, with 40 trackhoe reach.
wetland ex and haul					13,476	
Wetland restoration	279,852	1.0	279,852	10,365		
South Diversion Ditch	length	width	Depth	Volume (FT3)	Total (YD3)	
Place 12" gravel	4,300	6	1.0	25,800	956	
Wedge Buttres	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
Place buttress material			194,400	7,200		405' x 320 ft2 (x-section)
Place drain material	31,591	1.0	31,591	1,170		and .67 compaction factor
Alt. 2 Soil Cover						
(add wedge buttres)						
Place Soil Cover	Area	Depth	Total (FT3)	Total (YD3)		
TSDD-soil cover	2,163,349	0.5	1,081,675	40,062		Assumes some cover in place on average.
TSDD- topsoil	2,163,349	0.5	1,081,675	40,062		
Impoundment- soil cover	4,277,787	0.5	2,138,894	79,218		Excludes areas with > 18" soil cover.
Impoundment- top soil	4,277,787	0.5	2,138,894	79,218		No top soil on current areas >18"
Alt. 3 Source Removal						
TSDD - Partial Removal (outside ditch)	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
TSDD- tails ex and haul to impoundment			3,128,379	115,866		Total from model
TSDD- cover over tails			1,202,938	44,553		Cover removed with tails, from model.
TSDD- base below tails	963,732	0.5	481,866	17,847		Base removed with tails.
TSDD- Total to haul to impoundment					178,266	
TSDD- place topsoil	2,163,349	0.5	1,081,675	40,062	40,062	Topsoil on whole area
TSDD- place soil cover	1,484,560	0.5	742,280	27,492	27,492	soil cover - non removal areas
Impoundment						
Place Tailings (from TSDD AND Wetland)				178,266	191,742	Place in low northern area.
Place soil cover- over emplaced tailings	1,556,139	1.0	1,556,139	57,635		Per foot over low area.
Place soil cover	4,277,787	0.5	2,138,894	79,218		Excludes areas with > 18" soil cover
Total soil cover to be placed					136,853	
Place top soil	4,277,787	0.5	2,138,894	79,218	79,218	Excludes areas with > 18" soil cover.
runoff channel (on impundment)	21,000	2.0	42,000	1,556		Direct flow from impoundment into South Diversion Ditch
channel reconstruction in source removal area	20,000	2.0	40,000	1,481		After source removal in se area 1000x10x2.
Alt. 4 Offsite Disposal						
	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
TSDD- ex and haul to treatment/loadout			6,281,166	232,636		Total from model.
TSDD- cover over tails			3,295,240	122,046		Cover removed with tails, from model
TSDD- base below tails	2,163,349	0.5	1,081,675	40,062		Base removed with tails
TSDD- Total to haul to treatment/loadout					394,744	
TSDD- place topsoil	2,163,349	**0.5**	**1,081,675**	**40,062**	**40,062**	Whole Area.
Wetland ex and haul	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
ex and hual	279,852	1.0	6,281,166	232,636		
mitigation	279,852	1.0	6,281,166	232,636		
Total to treat					**232,636**	
Impoundment						
South Diversion Ditch ex and haul	25,800	3.5	6,281,166	232,636		
tails- excavate and haul to treat/loadout			48,870,611	1,810,023		Total from model.
cover- excavate and haul to treat/loadout			5,857,841	216,957		Total from model.
base- excavate and haul to treat/loadout	5,075,626	0.5	2,537,813	93,993		
Impoundment- Total to haul to treat/loadout					**2,353,609**	
Total material to treat					**2,980,988**	
Total material to dispose					4,471,482	Assume 1.5 swell factor.
impoundment-place toposoil	5,075,626	0.5	**2,537,813**	**93,993**	**93,993**	
Alt. 5 Offsite Disposal						
	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
TSDD- ex and haul to treatment/loadout			6,281,166	232,636		Total from model.
TSDD- cover over tails			3,295,240	122,046		Cover removed with tails, from model.
TSDD- base below tails	2,163,349	0.5	1,081,675	40,062		Base removed with tails.
TSDD- Total to haul to treatment/loadout	2,163,349				394,744	
TSDD- place topsoil	2,163,349	**0.5**	**1,081,675**	**40,062**	**40,062**	Whole area.
Wetland ex and haul	Area	Depth	Total (FT3)	SubTotal (YD3)	Total (YD3)	
Sediment ex and hual	279,852	1.0	6,281,166	232,636		
mitigation	279,852	1.0	6,281,166	232,636		
Total to treat					**232,636**	
Impoundment						
South Diversion Ditch ex and haul	25,800	3.5	6,281,166	232,636		
tails- excavate and haul to treat/loadout			48,870,611	1,810,023		Total from model.
cover- excavate and haul to treat/loadout			5,857,841	216,957		Total from model.
base- excavate and haul to treat/loadout	5,075,626	0.5	2,537,813	93,993		
Impoundment- Total to haul to treat/loadout					**2,353,609**	
Total material to treat					**2,980,988**	
Total material to replace on impoundment					4,471,482	Assume 1.5 swell factor.
impoundment-place toposoil	5,075,626	0.5	**2,537,813**	**93,993**	**93,993**	

Table 5-4
Cost Alternative 2
Soil Cover/Insitutional Controls

Direct Capital Costs	Quantity	Unit	Cost	Total Cost
Diversion Ditch				
Place 1' gravel cover	956	cyd	$12.00	$11,472.00
Signs	20	sign	$50.00	$1,000.00
		Subtotal		**$12,472.00**
Tailings South of Diversion Ditch				
Site preparation (clearing, grubbing..)	50	ac	$1,000.00	$50,000.00
Place soil cover (bring up to 12")	40,062	cy	$5.75	$230,356.50
Place topsoil (.5')	40,062	cy	$4.80	$192,297.60
Dust control	20	days	$735.00	$14,700.00
Reconstruct tributary channel	1,481	cy	$7.50	$11,107.50
revegetation	50	ac	$500.00	$25,000.00
		Subtotal		**$523,461.60**
Impoundment				
Site preparation (clearing, grubbing..)	115	ac	$1,000.00	$115,000.00
Place soil cover (bring up to 12")	79,218	cy	$5.75	$455,503.50
Place topsoil (.5')	79,218	cy	$4.80	$380,246.40
Construct drainage channel (to SDD)	1,667	cy	$7.50	$12,502.50
Dust control	20	days	$735.00	$14,700.00
Grading (stormwater runoff control)	80	hrs	$140.00	$11,200.00
revegetation	115	ac	$500.00	$57,500.00
		Subtotal		**$1,046,652.40**
Embankment (wedge buttress)				
Site preparation (clearing, grubbing..)	0.75	ac	$1,000.00	$750.00
Place drain material	1,170	cy	$8.00	$9,360.00
Place buttress material (includes compaction of lifts)	7,200	cy	$6.00	$43,200.00
Dust control	6	days	$735.00	$4,410.00
Erosion protection (stormwater runoff control)	300	cy	$12.00	$3,600.00
Revegetation	0.75	ac	$500.00	$375.00
		Subtotal		**$61,695.00**
Long-Term Operation and Maintenance Costs				
O&M	15	yr	$4,000.00	$60,000.00
Annual Sampling	15	yr	$2,000.00	$30,000.00
Reporting	15	yr	$5,000.00	$75,000.00
Develop Institutional Controls	1		$10,000.00	$10,000.00
Institutional Controls Monitoring and Repair (fencing, signs)	15	yr	$2,000.00	$30,000.00
		Subtotal		**$205,000.00**
			Total Direct Costs	**$1,849,281.00**
Indirect Capital Costs				
Engineering Design and Project Administration				$50,000.00
Monitoring Plan				$4,000.00
Construction Oversight (2.5 % of Direct Capital Cost)				$46,232.03
Contingency (15 % of Direct Capital Cost)				$277,392.15
Health and Safety (1 % of Capital Costs)				$18,492.81
EPA Oversight				$50,000.00
		Subtotal		**$446,116.99**
			Total Indirect Costs	**$446,116.99**
	TOTAL COSTS			**$2,295,397.99**

Table 5-5
Cost Alternative 3
Source Removal/ Soil Cover and Wedge Buttress

Direct Capital Costs	Quantity	Unit	Cost	Total Cost
Diversion Ditch				
Place 1' gravel cover	956	cyd	$12.00	$11,472.00
Signs	20	sign	$50 00	$1,000.00
		Subtotal		**$12,472.00**
Tailings South of Diversion Ditch				
Site preparation (clearing, grubbing..)	50	ac	$1,000.00	$50,000.00
Excavate and haul to impoundment (partial source removal)	178,266	cy	$5 75	$1,025,029.50
Place soil cover (bring up to 12", haul, spread, compact)	27,492	cy	$4.80	$131,961.60
Place topsoil (.5') excavated and covered areas	40,062	cy	$4.80	$192,297.60
Dust control	20	days	$735.00	$14,700.00
Reconstruct tributary channel	1,481	cy	$7.50	$11,107.50
Grading (stormwater runoff control)	24	hrs	$140.00	$3,360.00
Revegetation	50	ac	$500 00	$25,000.00
		Subtotal		**$1,453,456.20**
Wetland				
Place fill for trackhoe access	3,040	cy	$4 80	$14,592.00
Excavate and haul to impoundment	13,440	cy	$5.75	$77,280.00
Restoration	10,400	cy	$10.00	$104,000.00
Silver Creek diversion	500	cy	$7.50	$3,750.00
Revegetation	7	ac	$500.00	$3,250.00
		Subtotal		**$202,872.00**
Impoundment				
Site preparation (clearing, grubbing..)	115	ac	$1,000.00	$115,000.00
Place tailings from TSDD and Wetland (grade and compact)	191,742	cy	$1.50	$287,613.00
Place soil cover (bring up to 12", haul, spread, compact)	136,853	cy	$4.80	$656,894.40
Construct drainage channel (to SDD)	1,556	cy	$7 50	$11,670 00
Place topsoil (5')	79,218	cy	$4 80	$380,246.40
Dust control	20	days	$735.00	$14,700.00
Grading (stormwater runoff control)	80	hrs	$140.00	$11,200.00
revegetation	115	ac	$500 00	$57,500.00
		Subtotal		**$1,534,823.80**
Embankment (wedge buttress)				
Site preparation (clearing, grubbing..)	0 75	ac	$1,000.00	$750.00
Place drain material	1,210	cy	$8.00	$9,680.00
Place buttress material (includes compaction of lifts)	7,200	cy	$6.00	$43,200.00
Dust control	6	days	$735 00	$4,410 00
Erosion protection (stormwater runoff control)	300	cy	$7.50	$2,250 00
Revegetation	0 75	ac	$750 00	$562.50
		Subtotal		**$60,852.50**
Long-Term Operation and Maintenance Costs				
O&M	15	yr	$4,000.00	$60,000.00
Annual Sampling	15	yr	$2,000.00	$30,000.00
Reporting	15	yr	$5,000.00	$75,000 00
Develop Institutional Controls	1		$5,000 00	$5,000.00
Institutional Controls Monitoring and Repair (fencing, signs)	15	yr	$5,000 00	$75,000 00
		Subtotal		**$245,000.00**
			Total Direct Costs	**$3,509,476.50**
Indirect Capital Costs				
Engineering Design and Project Administration				$50,000.00
Monitoring Plan				$4,000 00
Construction Oversight (2 5 % of Direct Capital Cost)				$87,736 91
Contingency (15 % of Direct Capital Cost)				$526,421 48
Health and Safety (1 % of Capital Costs)				$35,094.77
EPA Oversight				$50,000 00
		Subtotal		**$753,253.15**
			Total Indirect Costs	**$753,253.15**
	TOTAL COSTS			**$4,262,729.65**

Table 5-6
Cost Alternative 4
Excavation, Treatment and Offsite Disposal

Direct Capital Costs	**Quantity**	**Unit**	**Cost**	**Total Cost**	
Diversion Ditch (removal)					
Remove sediments and tailings haul to treatment	232,636	cy	$6.00	$1,395,816.00	
revegetation	2	ac	$500.00	$1,000.00	
		Subtotal		**$1,396,816.00**	
Tailings South of Diversion Ditch					
Site preparation (clearing, grubbing..)	50	ac	$1,000.00	$50,000 00	
Excavate and haul to treatment/loadout (tails, base and exs. cover)	394,744	cy	$5.75	$2,269,778.00	
Place topsoil	40,062	cy	$4.80	$192,297.60	
Dust control	20	days	$735.00	$14,700.00	
Reconstruct tributary channel	1,481	cy	$7.50	$11,107 50	
Grading (reclamation and stormwater runoff control)	40	hrs	$140.00	$5,600.00	
revegetation	50	ac	$500.00	$25,000.00	
		Subtotal		**$2,568,483.10**	
Impoundment					
Site preparation (clearing, grubbing..)	115	ac	$1,000.00	$115,000.00	
Excavate tailings, base and existing cover, haul to loadout	2,353,609	cy	$5.75	$13,533,251.75	
Place topsoil	93,993	cy	$4.80	$451,166 40	
Reconstruct original channel	3,911	cy	$7.50	$29,332 50	
Dust control	30	days	$735.00	$22,050.00	
Grading (stormwater runoff control)	40	hrs	$140.00	$5,600.00	
revegetation	115	ac	$500.00	$57,500.00	
		Subtotal		**$14,213,900.65**	
Embankment					
excavate and haul	65,290	cy	$5 75	$375,417.50	
Dust control	8	days	$735.00	$5,880.00	
Erosion protection (stormwater runoff control)	500	cy	$7.50	$3,750.00	
Revegetation	2	ac	$500.00	$1,000.00	
		Subtotal		**$386,047.50**	
Wetland					
Place fill for trackhoe access	3,040	cy	$4.80	$14,592 00	
Excavate and haul to treatment/loadout	13,440	cy	$5 75	$77,280.00	
Wetland restoration	10,365	cy	$10.00	$103,650.00	
Silver Creek diversion	500	cy	$7 50	$3,750.00	
		Subtotal		**$199,272.00**	
Stabilization and disposal - ECDC					
Dust control	30	days	$735 00	$22,050.00	
Erosion protection (stormwater runoff control)	1,000	cy	$7.50	$7,500.00	
Stabilization	2,980,988	cy	$30.00	$89,429,640.00	
Load to trucks	4,471,482	cy	$1.50	$6,707,223.00	
Haul to landfill (43 ton belly dump trucks)	4,471,482	cy	$9 00	$40,243,338.00	
disposal fees	4,471,482	cy	$30 00	$134,144,460.00	
Sample analysis	250	sample	$150.00	$37,500.00	
		Subtotal		**$270,591,711.00**	
Long-Term Operation and Maintenance Costs					
O&M	15	yr	$4,000.00	$60,000 00	
Annual Sampling	15	yr	$2,000.00	$30,000 00	
Reporting	15	yr	$5,000 00	$75,000 00	
Develop Institutional Controls	1		$10,000 00	$10,000 00	
Institutional Controls Monitoring and Repair	15	yr	$2,000 00	$30,000 00	
		Subtotal		**$205,000.00**	
			Total Direct Costs		**$289,561,230.25**
Indirect Capital Costs					
Engineering Design and Project Administration				$50,000 00	
Monitoring Plan				$4,000 00	
Construction Oversight (2.5 % of Direct Capital Cost)				$7,239,030 76	
Contingency (15 % of Direct Capital Cost)				$43,434,184 54	
Health and Safety (1 % of Capital Costs)				$2,895,612 30	
EPA Oversight				$50,000.00	
		Subtotal		**$53,672,827.60**	
			Total Indirect Costs		**$53,672,827.60**
TOTAL COSTS					**$343,234,057.85**

Table 5-7
Cost Alternative 5
Onsite Treatment and Disposal

Direct Capital Costs	Quantity	Unit	Cost	Total Cost	
Diversion Ditch					
Remove sediments and tailings haul to treatment	232,636	cy	$6.00	$1,395,816.00	
revegetation	2	ac	$500.00	$1,000 00	
		Subtotal		**$1,396,816.00**	
Tailings South of Diversion Ditch					
Site preparation (clearing, grubbing..)	50	ac	$1,000.00	$50,000.00	
Excavate and haul to treatment (tails and exs. cover)	394,744	cy	$5.75	$2,269,778.00	
Place topsoil	40,062	cy	$4.80	$192,297 60	
Dust control	20	days	$735.00	$14,700 00	
Reconstruct tributary channel	1,481	lf	$7.50	$11,107.50	
Grading (reclamation and stormwater runoff control)	40	hrs	$140.00	$5,600.00	
revegetation	50	ac	$500.00	$25,000.00	
		Subtotal		**$2,568,483.10**	
Impoundment					
Site preparation (clearing. grubbing .)	115	ac	$1,000.00	$115,000.00	
Excavate tailings and existing cover, haul to loadout	2,353,609	cy	$5.75	$13,533,251.75	
Place topsoil	93,993	cy	$4.80	$451,166.40	
replace treated materials	4,471,482	cy	$1.50	$6,707,223.00	
construct drainage channel (center to SDD)	3,911	cy	$7.50	$29,332.50	
Dust control	30	days	$735.00	$22,050.00	
Grading (stormwater runoff control)	40	hrs	$140.00	$5,600.00	
revegetation	115	ac	$500.00	$57,500.00	
		Subtotal		**$20,921,123.65**	
Embankment					
excavate and haul	65,290	cy	$5.75	$375,417.50	
Dust control	8	days	$735.00	$5,880.00	
Erosion protection (stormwater runoff control)	500	cy	$7 50	$3,750 00	
Revegetation	2	ac	$500.00	$1,000.00	
		Subtotal		**$386,047.50**	
Wetland					
Place fill for trackhoe access	3,040	cy	$4.80	$14,592 00	
Excavate and haul to treatment/loadout	13,440	cy	$5.75	$77,280.00	
Wetland restoration	10,365	cy	$10.00	$103,650.00	
Silver Creek diversion	500	cy	$7.50	$3,750.00	
		Subtotal		**$199,272.00**	
Stabilization and Disposal - Onsite					
Dust control	60	days	$735.00	$44,100 00	
Erosion protection (stormwater runoff control)	1,000	cy	$7.50	$7,500.00	
Stabilization	2,980,988	cy	$30.00	$89,429,640.00	
Load to trucks, haul to impoundment	4,471,482	cy	$1.50	$6,707,223.00	
Sample analysis	250	sample	$150.00	$37,500.00	
		Subtotal		**$96,225,963.00**	
Long-Term Operation and Maintenance Costs					
O&M	15	yr	$4,000.00	$60,000.00	
Annual Sampling	15	yr	$2,000 00	$30,000.00	
Reporting	15	yr	$5,000.00	$75,000 00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
Institutional Controls Monitoring and Repair	15	yr	$2,000.00	$30,000.00	
		Subtotal		**$205,000.00**	
			Total Direct Costs		**$121,902,705.25**
Indirect Capital Costs					
Engineering Design and Project Administration				$50,000.00	
Monitoring Plan				$4,000.00	
Construction Oversight (2 5 % of Direct Capital Cost)				$3,047,567 63	
Contingency (15 % of Direct Capital Cost)				$18,285,405 79	
Health and Safety (1 % of Capital Costs)				$1,219,027 05	
EPA Oversight				$200,000.00	
		Subtotal		**$22,806,000.47**	
			Total Indirect Costs		**$22,806,000.47**
	TOTAL COSTS				**$144,708,705.72**

Table 6-1

Ranking of Final Alternatives

Criteria	Ranking Weight (1)	Alternative 1 No Action		Alternative 2 Soil Cover/ Institutional Controls		Alternative 3 Source Removal, Soil Cover and Wedge Buttress		Alternative 4 Excavation, Treatment and Offsite Disposal		Alternative 5 Excavation, Treatment and Onsite Disposal	
OVERALL PROTECTIVENESS		Rank (2)	Weight Factored Rank (3)	Rank (2)	Weight Factored Rank (3)	Rank (2)	Weight Factored Rank (3)	Rank (2)	Weight Factored Rank (3)	Rank (2)	Weight Factored Rank (3)
Human Health	10	1	10	4	40	4	40	5	50	5	50
Environmental protection	10	1	10	2	20	4	40	5	50	5	50
COMPLIANCE WITH ARARS											
Chemical-specific ARAR	8	1	8	2	16	3	24	5	40	5	40
Location-specific ARAR	5	1	5	2	10	4	20	5	25	4	20
Action-specific ARAR	5	1	5	3	15	4	20	5	25	4	20
Other criteria/guidance	5	1	5	2	10	2	10	5	25	4	20
LONG-TERM EFFECTIVENESS AND PERMANENCE											
Magnitude of residual risk	9	1	9	3	27	4	36	5	45	5	45
Adequacy and reliability of controls	8	1	8	3	24	4	32	5	40	5	40
REDUCTION OF TOXICITY, MOBILITY OR VOLUME											
Treatment process used	5	1	5	1	5	1	5	5	25	5	25
Amount destroyed or treated	5	1	5	1	5	1	5	4	20	4	20
Reduction of toxicity, mobility or volume treatment	7	1	7	2	14	3	21	5	35	4	28
Statutory preference for treatment	10	1	10	1	10	1	10	5	50	5	50
SHORT TERM EFFECTIVENESS											
Community protection	5	1	5	4	20	4	20	1	5	2	10
Worker protection	4	1	4	4	16	4	16	1	4	2	8
Environmental impacts	5	1	5	2	10	4	20	1	5	2	10
Time until action is complete	2	1	2	4	8	3	6	1	2	2	4
IMPLEMENTABILITY											
Ability to construct and operate	9	5	45	4	36	4	36	1	9	2	18
Ease of additional remediation, if needed	5	4	20	3	15	4	20	5	25	1	5
Ability to monitor effectiveness	6	5	30	3	18	5	30	5	30	4	24
Ability to obtain approval from other agencies	5	1	5	2	10	4	20	5	25	4	20
Availability of services and capacities	3	4	12	3	9	4	12	5	15	2	6
Availability of equipment, specialists and materials	3	4	12	5	15	4	12	5	15	2	6
Availability of technology	3	4	12	5	15	4	12	5	15	2	6
RANKING TOTALS		**43**	**239**	**65**	**368**	**79**	**467**	**94**	**580**	**80**	**525**
COST											
Present worth cost		$0.00		$2,295,397.99		$4,262,729.65		$343,234,057.85		$144,708,705.72	

(1) - Each criteria has been ranked on an overall project importance weight of 1-10 with 1 signifying the least importance and 10 signifying the greatest importance.

(2) - The compliance of each criteria has been ranked on an alternative by alternative basis on a scale of 1-5 with 1 signifying the least compliance and 5 signifying the greatest compliance.

(3) - Ranking weight multiplied by the compliance rank for each alternative

Appendix A
Stability Evaluation, Richardson Flat Tailings Embankment

AGEC
Applied Geotechnical Engineering Consultants, Inc.

October 4, 2001

United Park City Mines Company
PO Box 1450
Park City, UT 84060

Attention: Kerry Gee
Fax (435) 649-8035

Subject: Stability Evaluation
Richardson Flat Tailings Embankment
Near Park City, Utah
Project No. 1010603

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc. was requested to perform a stability evaluation for the Richardson Flat tailings embankment located near Park City, Utah (see Figure 1). The study was performed to estimate the increase in stability of the embankment once a buttress fill was placed along the toe of the embankment. Our study included a review of geotechnical and hydrogeologic studies which were previously performed at the site by others and a reconnaissance of the site. No subsurface investigation was performed for this study.

HISTORY

We understand that the Richardson Flat area was first used for a tailings pond during 1953 with enlargements of the tailings pond area through construction of containment dikes and embankments during the 1970's.

In 1974, Dames and Moore performed a geotechnical investigation to provide recommendations for construction of embankments and dikes for the tailings pond and provided specific recommendations for construction of the enlarged embankment. Subsequent study was performed in 1980 to evaluate the construction which occurred. Results of that study indicate that construction which occurred in 1974 did not fully meet the recommendations provided. The Dames and Moore report indicates that "while the most objectionable foundation materials appear to have been largely removed, stripping was inadequate in places, side slopes were locally oversteepened, internal zoning was not as recommended and compaction was poor overall." Our understanding is that the embankment has remained generally in the condition as described in 1980 by Dames and Moore and has shown no evidence of stability problems.

SITE CONDITIONS

The main embankment under present conditions, extends approximately 400 feet in length in a general east/west direction and reaches a maximum height of approximately 26 feet near the east end of the embankment. The slope of the exterior of the embankment varies considerably, particularly on the west end. The steepest embankment slopes are generally along the east end where the exterior slope of the embankment is at a slope of approximately 1.5 horizontal to 1 vertical.

The interior of the tailings pond has been filled with tailings to near the top of the main embankment and has a gentle slope down toward the south. The ground surface is also relatively flat north of the main embankment with a very gently slope down toward the northeast.

Vegetation in the interior of the pond consists of grass, brush and weeds. Vegetation near the toe of the slope is relatively dense consisting predominantly of grass, brush and small trees. Vegetation along the exterior slope of the main embankment consists of grass and brush.

There is evidence of seepage near the toe of the embankment based on the vegetation type in this area.

SUBSURFACE CONDITIONS

The assumed subsurface conditions in the area of the embankment are based on 2 borings drilled by Dames and Moore and during their study reported 1974. The embankment materials encountered at that time consisted of fill in the upper approximately 22 feet, topsoil which was indicated to extend to a depth on the order of 28 feet underlain by silty sand and clay which was underlain by bedrock at a depth of approximately 32 feet in Boring B-1. Some of the fill as described contain wood, debris and other deleterious materials which we understand were mostly removed during the reconstruction and enlargement of the embankment in 1974. Natural soil obtained from the area west of the embankment was used as fill for enlargement and raising of the main embankment. We understand that this material consists predominantly of clayey sand and gravel. Placement of the additional material increased the height of the embankment by approximately 8 feet.

We understand that the subsurface water level is relatively shallow at the interior of the main embankment. There are seeps near the toe of the exterior of the main embankment.

ENGINEERING ANALYSIS

Profiles of the main embankment were developed at 2 locations based on a description of subsurface conditions available from previous studies. The locations of these 2 profiles are presented on Figure 2 and the profiles are presented on Figures 3 and 4. The assumed strengths of these materials are considered conservative with the assumed strengths indicated on Figures 3 and 4. Rotational failure analyses were conducted on the profiles aided by a computer using the Bishop method of analysis. Print-outs of stability runs are included in the Appendix.

The stability of the embankment under its present condition using the assumed strength parameters is estimated to be slightly greater than 1. We anticipate that the stability of the embankment is greater than that calculated.

Placement of a buttress fill along the lower portion of the embankment will significantly increase the overall stability of the embankment. Flattening of the exterior of the embankment will also provide increased stability.

We estimate that there would be an approximate 50 percent increase in overall stability of the embankment if a buttress fill is placed along the lower portion of the embankment with the height of the buttress fill approximately 10 feet above the embankment toe elevation and extending horizontally out from the embankment slope face approximately 30 feet. The buttress fill would have an exterior slope of 2 horizontal to 1 vertical. A similar increase is obtained for a buttress fill which extends 15 feet above the embankment toe elevation, extends approximately 20 feet horizontally out from the face of the embankment slope and has an exterior slope of 2 horizontal to 1 vertical. Flattening of the embankment to 3 horizontal to 1 vertical by placement of a wedge of material along the exterior of the embankment would increase the overall stability approximately 50 percent.

For each of these options, we recommend that the vegetation and upper soil which contains a significant amount of organics, be removed prior to placement of the fill. Drain material should be place above the prepared subgrade to allow for interception of seepage which may be encountered in the embankment. A filter blanket may be required to prevent particle migration into the drain. The drain should be designed to allow for removal of seepage water encountered.

Buttress fill materials may consist of most any soil types exclusive of organics, topsoil, debris and other deleterious materials. The use of fine grain materials such as clays and silts, may encounter greater difficulty in obtaining adequate compaction of the fill, particularly during the cold or wet time of the year. The fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D-698 at a moisture content within 2 percent of optimum.

The buttress fill should be protected from erosion through vegetation or other methods.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from studies performed by others and a site reconnaissance. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface conditions or groundwater levels are found to be significantly different from those described above, we should be notified so that we can re-evaluate our recommendations.

We appreciate the opportunity of providing this service to you. If you have any questions, or if we can be of further service, please call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Douglas R. Hawkes, P.E., P.G

Reviewed by JRM, P.E.
DRH/dc
enclosures

REFERENCES

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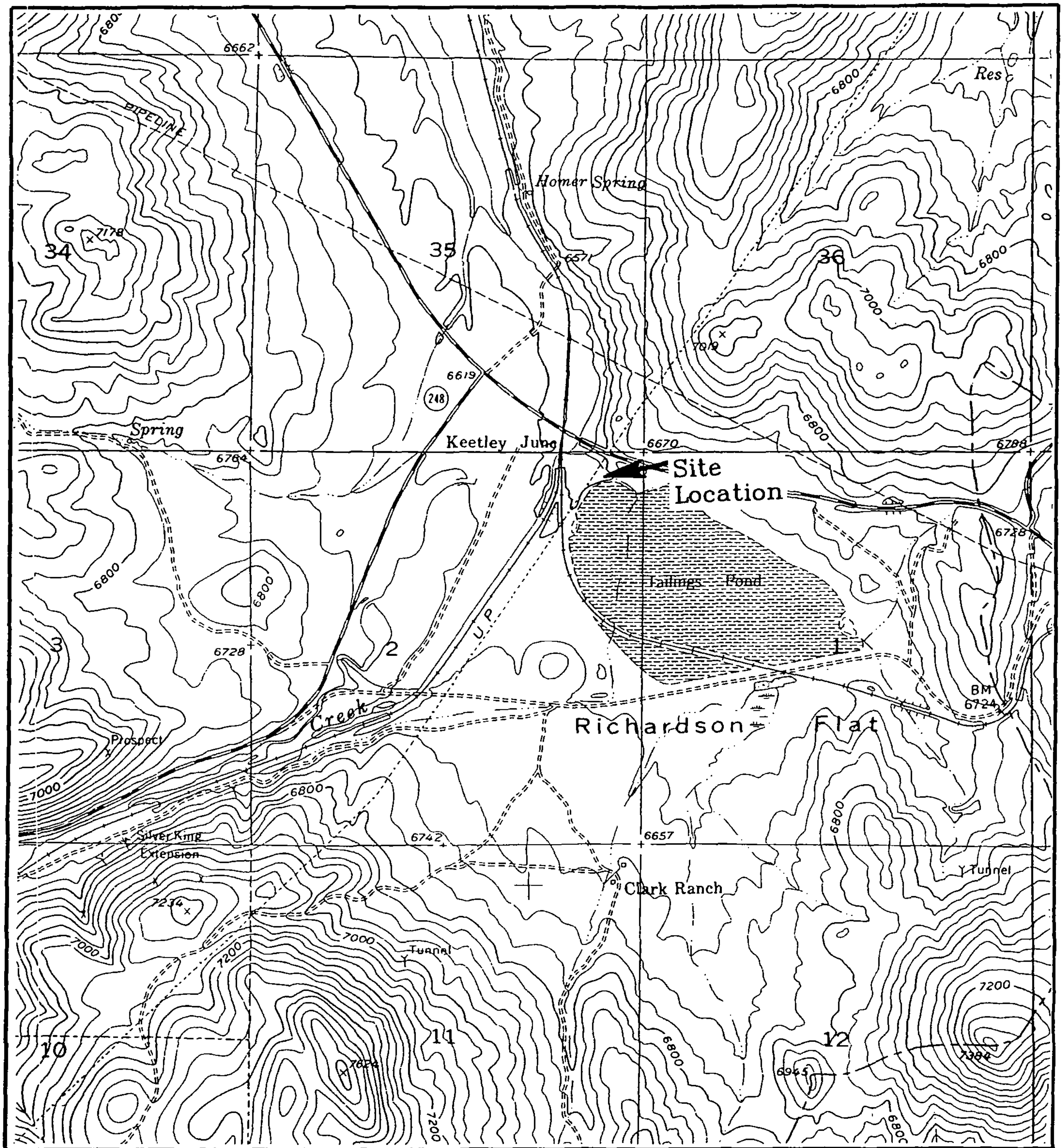
Dames & Moore, 1974, Report of Embankment and Dike Design Requirements, Proposed Tailings Pond Development, near Park City, Utah: Consultant's report prepared for Park City Ventures Corporation, March 1974.

Dames & Moore, 1980, Report on Tailings Pond Investigation, near Park City, Utah: Consultant's report prepared for Noranda Mining, Inc., November 1980.

Weston Engineering, Inc., 1999, Preliminary Hydrologic Review of Richardson Flats Tailings Site, sections 1 and 2, Township 2 South, Range 4 East, Summit County, Utah: Consultant's report prepared for Le Boeuf, Lamb, Greene & Mac Rae, LLP, March 1999.



From USGS Quadrangle
Park City East, Utah

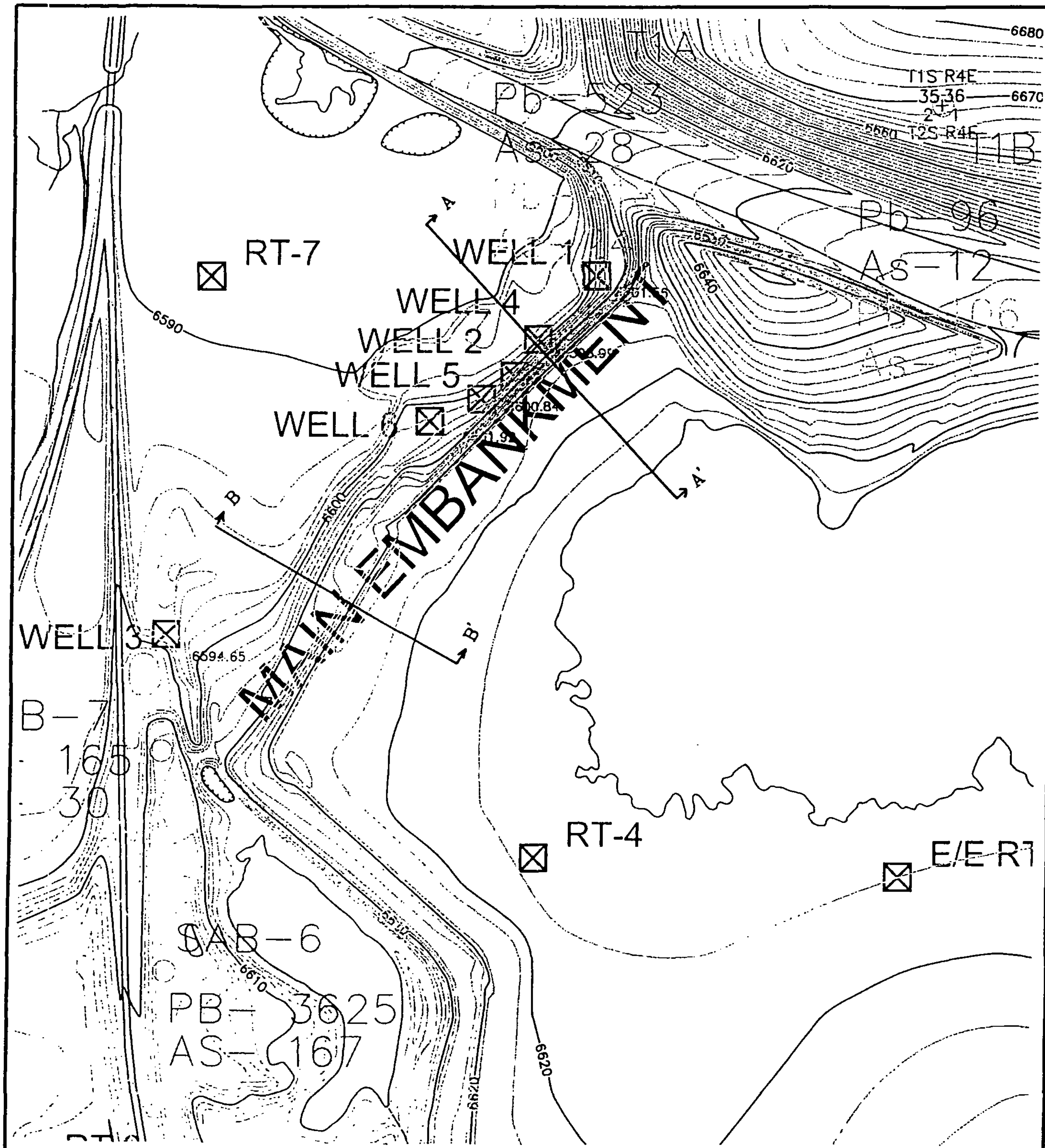
N

Approximate Scale

1" = 2,000'

STABILITY EVALUATION
RICHARDSON FLAT TAILINGS EMBANKMENT
NEAR PARK CITY, UTAH

1010603	AGEC	Location of Site	Figure 1



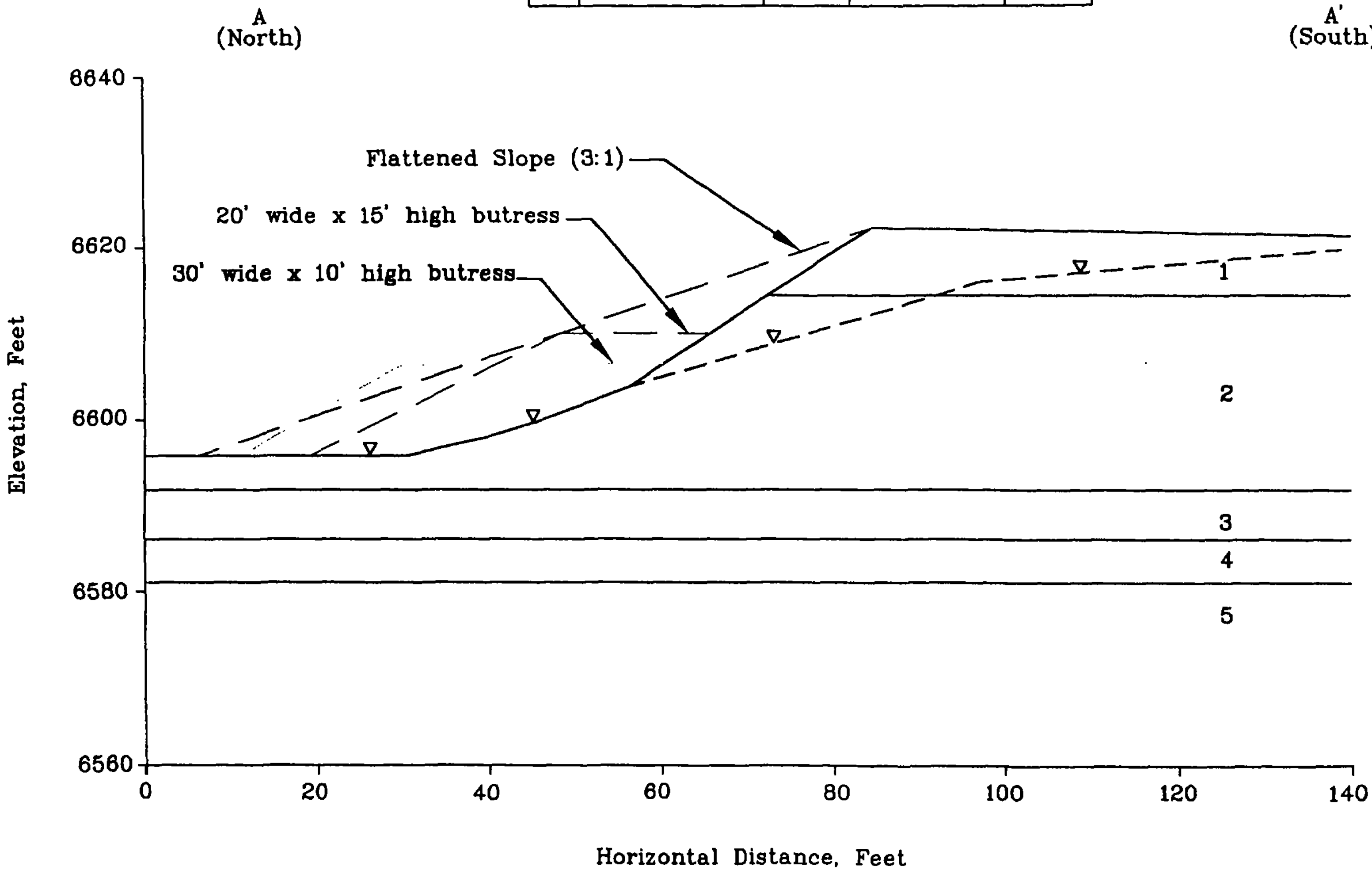
N

0 200 400 feet
Approximate Scale

STABILITY EVALUATION
RICHARDSON FLAT TAILINGS EMBANKMENT
NEAR PARK CITY, UTAH

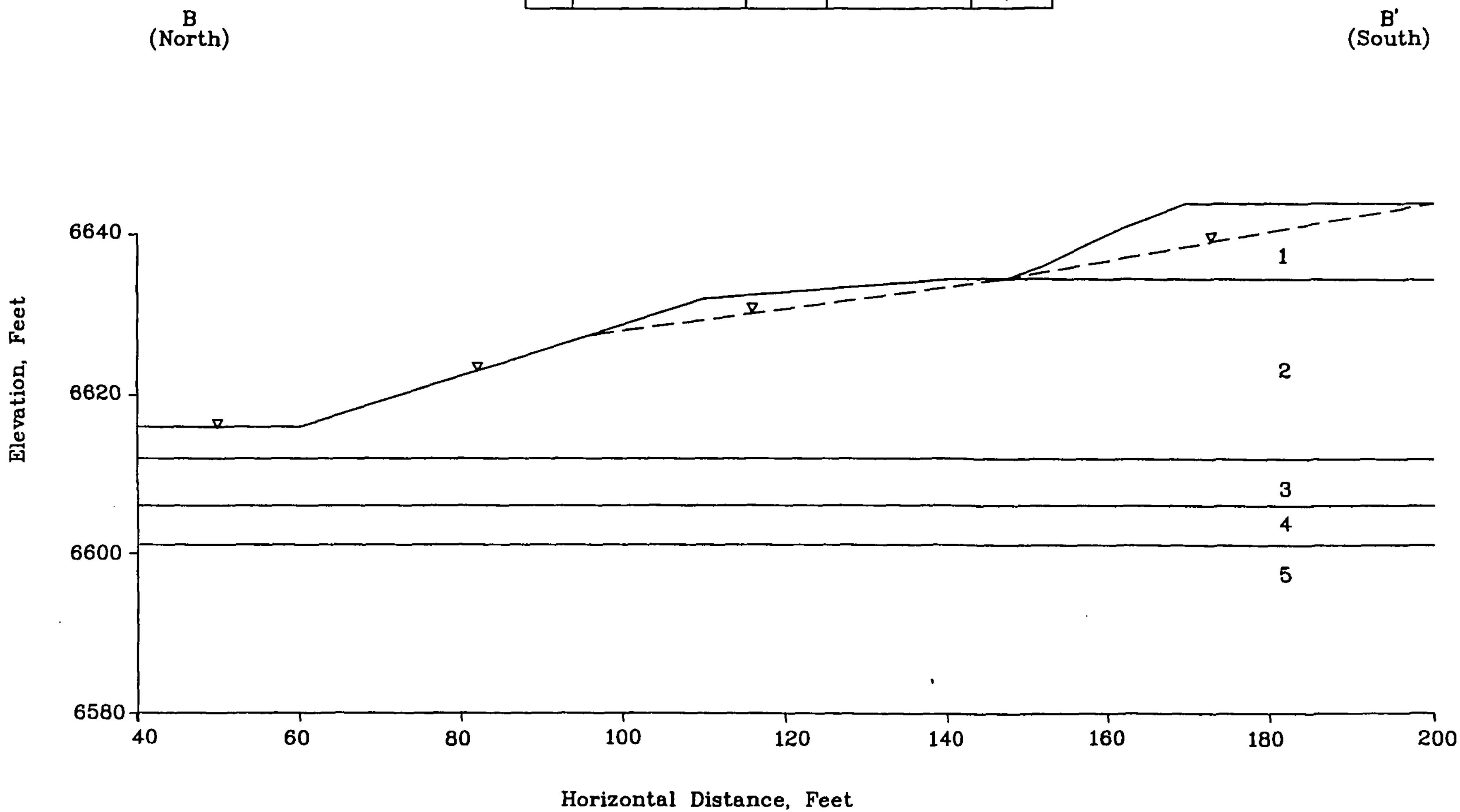
1010603	AGEC	Site Plan	Figure 2

Soil/Bedrock Parameters				
Unit	Soil/Bedrock	Density pcf	Friction Angle degrees	Cohesion psf
1	Fill; Clayey Gravel	130	37	200
2	Fill; Clay	120	20	150
3	Topsoil	120	20	150
4	Silty Sand	120	36	0
5	Bedrock	140	36	5,000



101060 AGEC Cross-Section, A-A' [illegible]ure 3

Soil/Bedrock Parameters				
Unit	Soil/Bedrock	Density pcf	Friction Angle degrees	Cohesion psf
1	Fill; Clayey Gravel	130	37	200
2	Fill; Clay	120	20	150
3	Topsoil	120	20	150
4	Silty Sand	120	36	0
5	Bedrock	140	36	5,000



101060 AGEC Cross-Section, B–B'

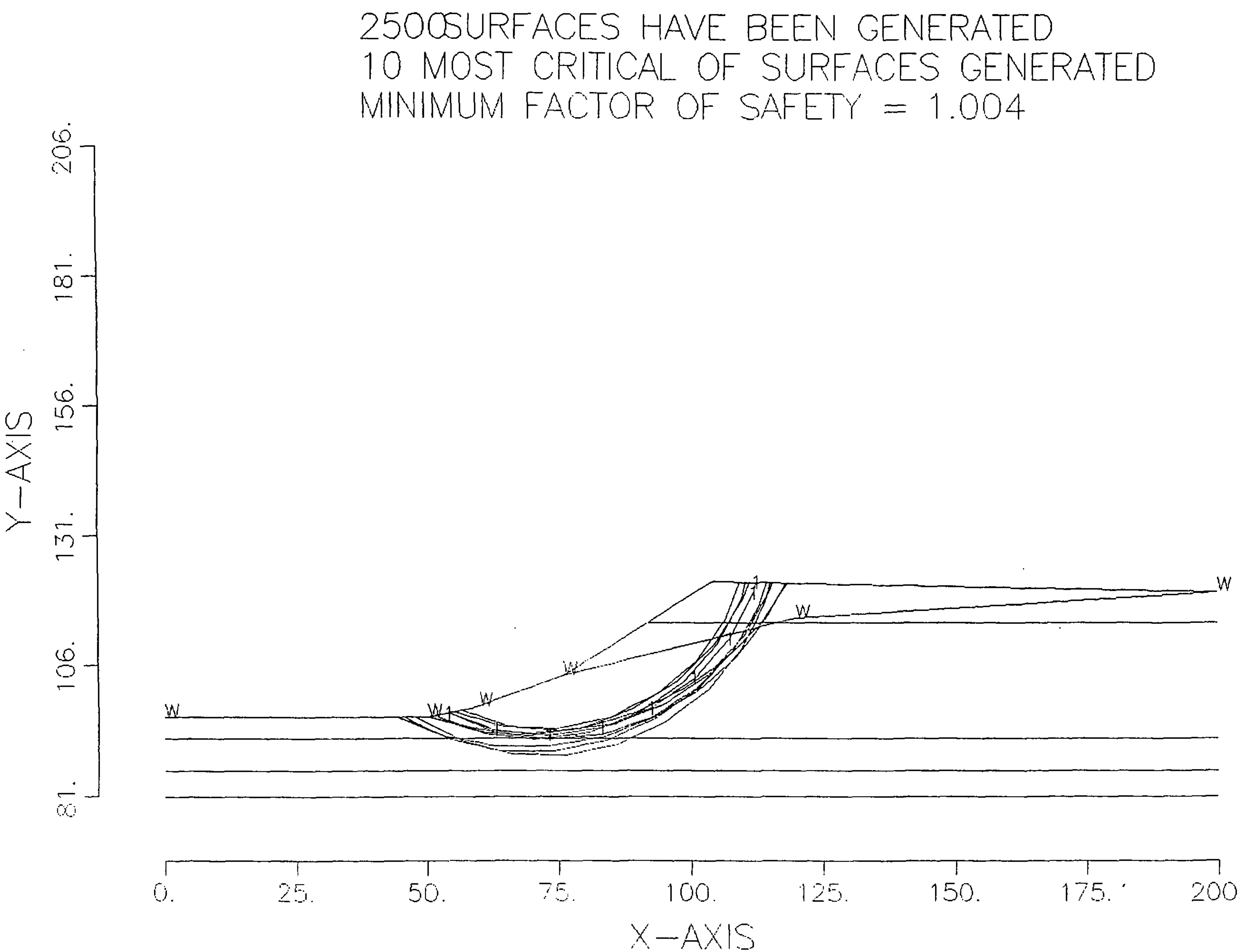
APPENDIX

SLOPE STABILITY ANALYSIS PRINTOUT

Project No. 1010603

AG:
Midvale UT s/n5206

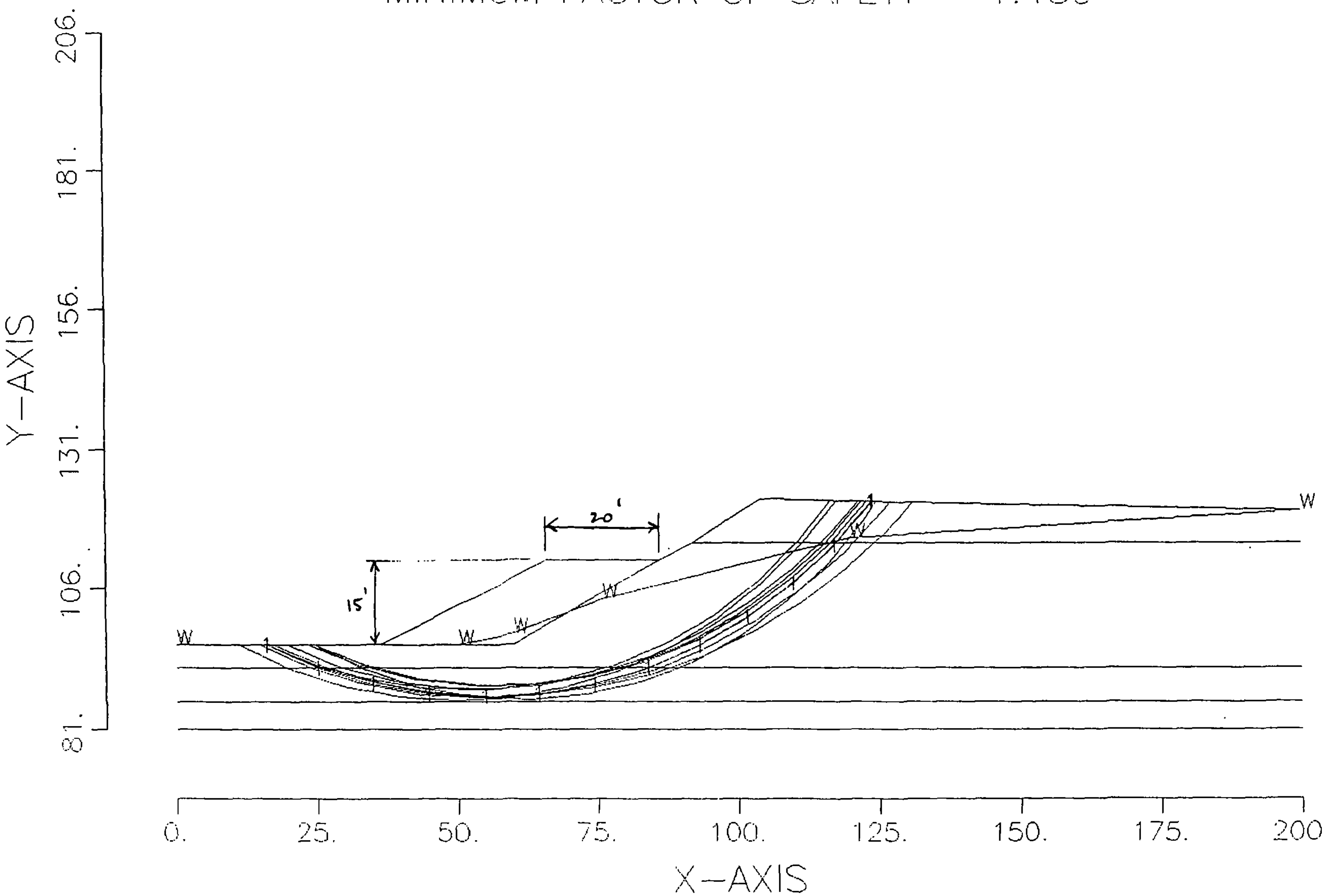
Richardson A-A'



AGE
Midvale UT s/n5206

Richardson A-A'

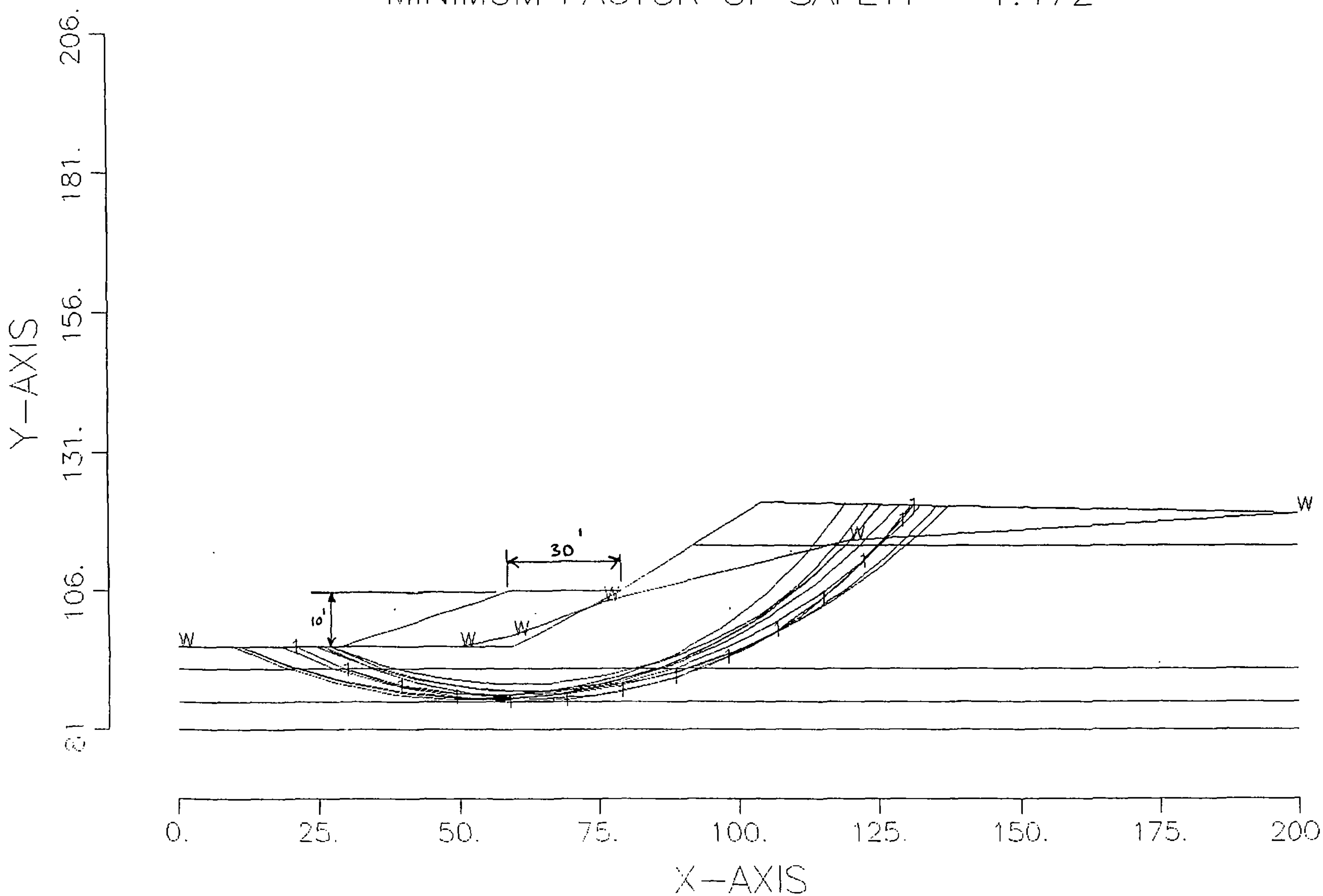
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.459



AGT
Midvale UT s/n5206

Richardson A-A'

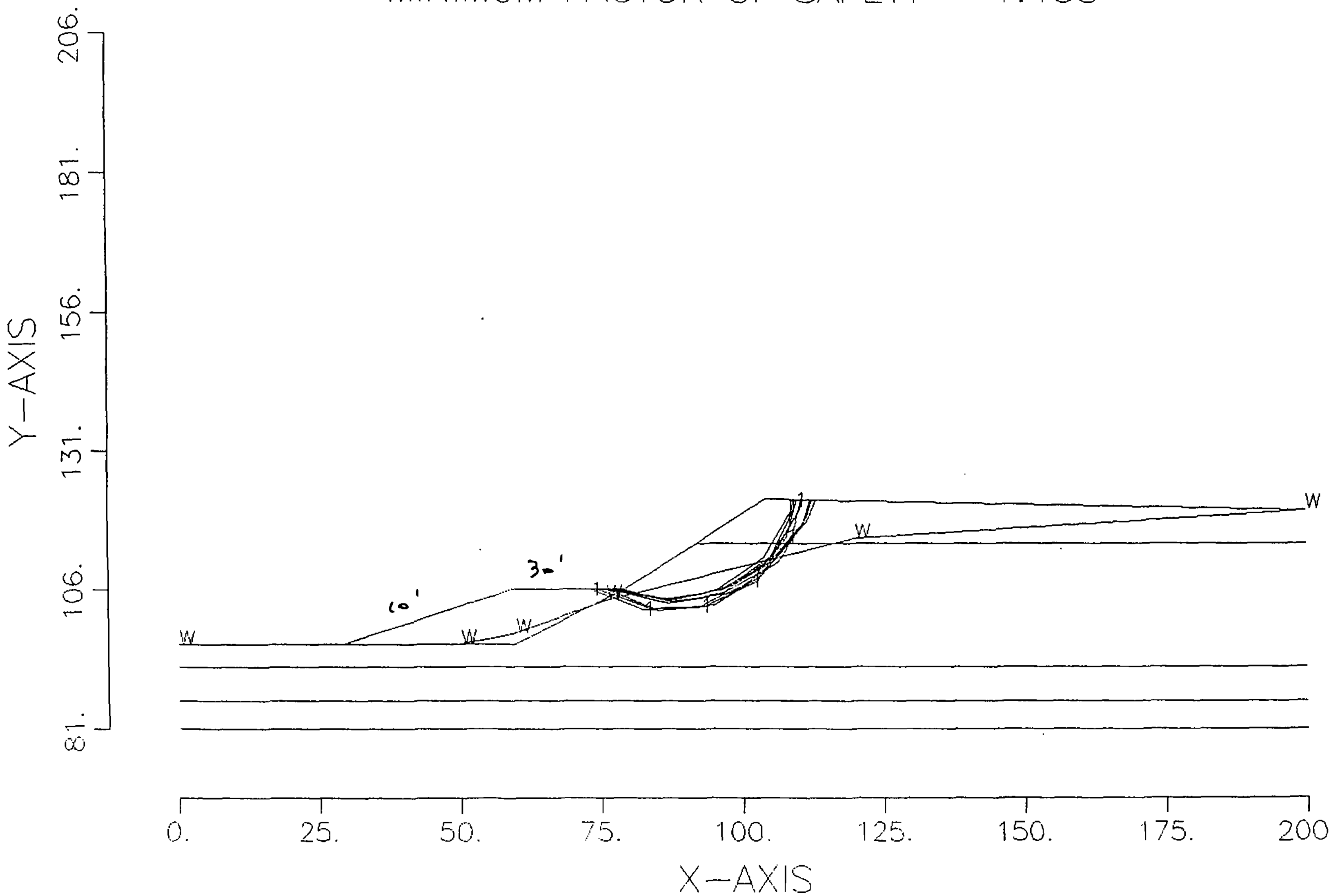
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.472



AGI
Midvale UT s/n5206

Richardson A–A'

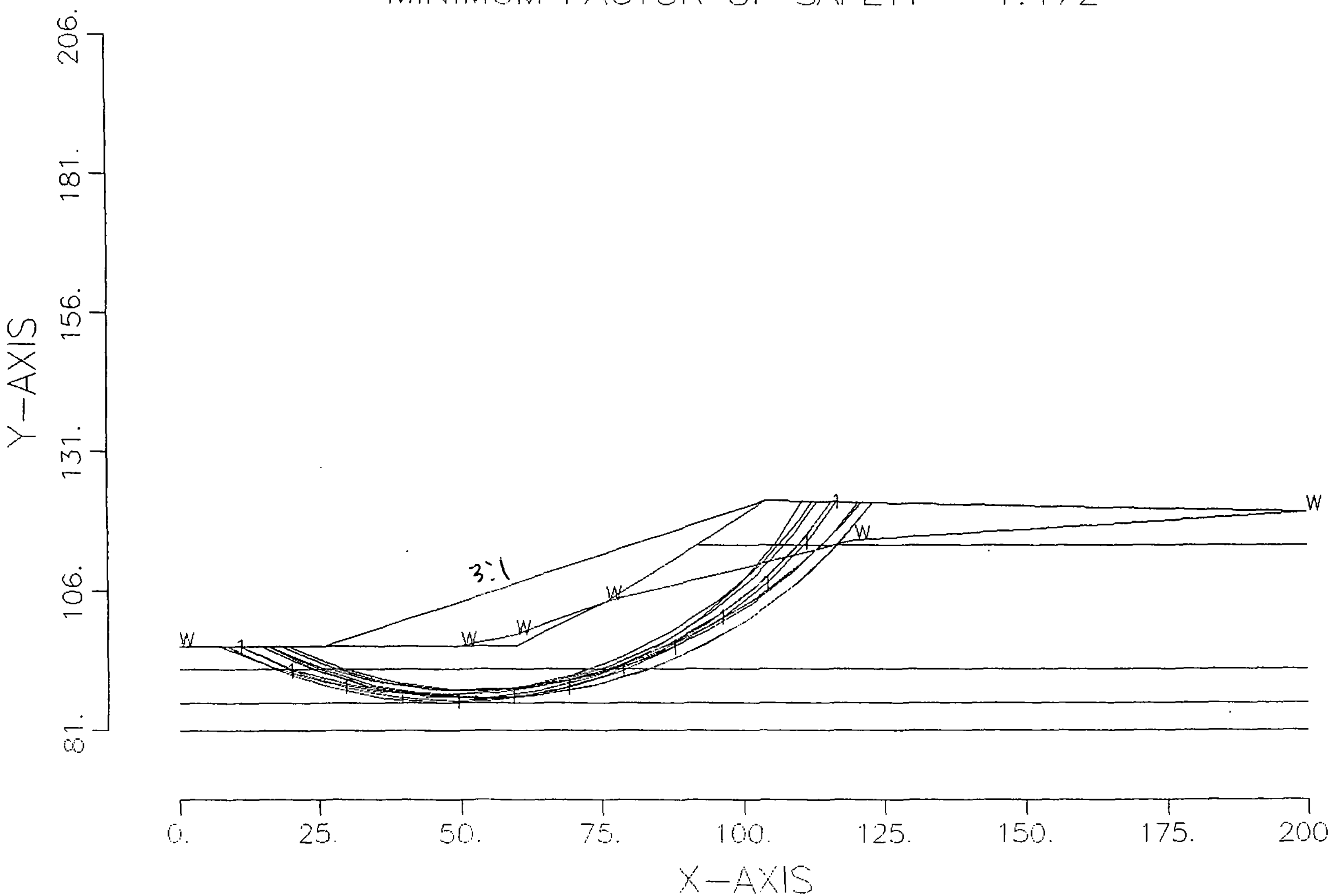
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.455



AGEC
Midvale UT s/n5206

Richardson A–A'

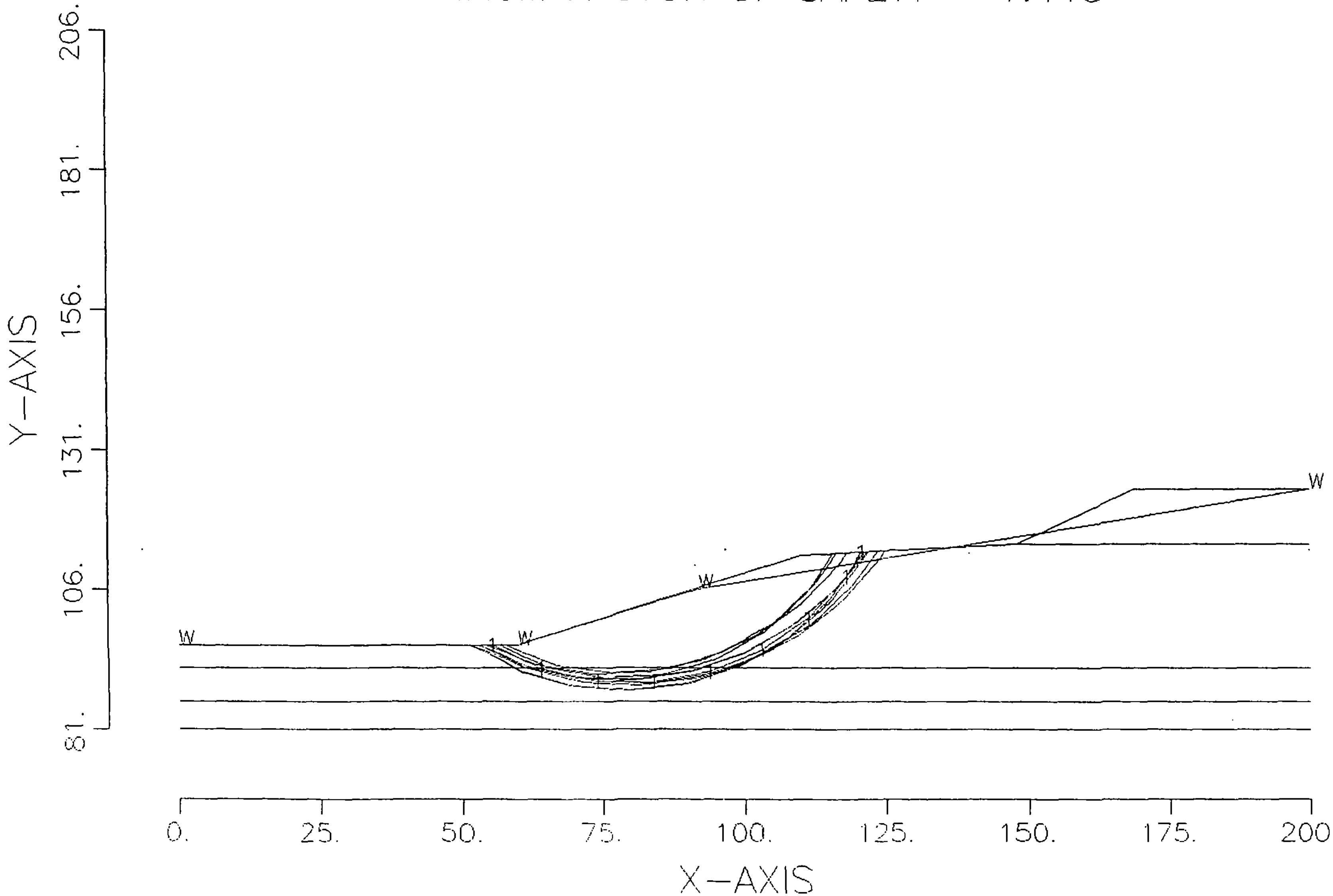
2500 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.472



AGE
Midvale UT s/n5206

Richardson B–B'

2500 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.415



--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION Richardson A-A'

BOUNDARY COORDINATES

6 TOP BOUNDARIES
10 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	96.00	50.00	96.00	2
2	50.00	96.00	60.00	98.00	2
3	60.00	98.00	76.00	104.00	2
4	76.00	104.00	92.00	114.00	2
5	92.00	114.00	104.00	122.00	1
6	104.00	122.00	200.00	120.00	1
7	92.00	114.00	200.00	114.00	2
8	.00	92.00	200.00	92.00	3
9	.00	86.00	200.00	86.00	4
10	.00	81.00	200.00	81.00	5

ISOTROPIC SOIL PARAMETERS

5 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	200.0	37.0	.00	.0	1
2	120.0	120.0	150.0	20.0	.00	.0	1
3	120.0	120.0	150.0	20.0	.00	.0	1
4	120.0	120.0	.0	36.0	.00	.0	1
5	140.0	140.0	5000.0	36.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	96.00
2	50.00	96.00
3	60.00	98.00
4	76.00	104.00
5	120.00	115.00
6	200.00	120.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

2500 TRIAL SURFACES HAVE BEEN GENERATED.

50 SURFACES INITIATE FROM EACH OF 50 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 60.00

EACH SURFACE TERMINATES BETWEEN X = 100.00
AND X = 200.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

1
AGEC
Midvale UT s/n5206

FAILURE SURFACE # 1 SPECIFIED BY 9 COORDINATE POINTS

SAFETY FACTOR = 1.004

X-CENTER = 72.27
Y-CENTER = 135.27
RADIUS = 42.66

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	53.88	96.78	-18.81
2	63.34	93.55	-5.35
3	73.30	92.62	8.11
4	83.20	94.03	21.58
5	92.50	97.71	35.04
6	100.69	103.45	48.50
7	107.31	110.94	61.96
8	112.02	119.77	75.42
9	112.55	121.82	

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION   Richardson A-A' - 20' X 15' Buttress

BOUNDARY COORDINATES

6 TOP BOUNDARIES
12 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	96.00	36.00	96.00	2
2	36.00	96.00	66.00	111.00	6
3	66.00	111.00	86.00	111.00	6
4	86.00	111.00	92.00	114.00	2
5	92.00	114.00	104.00	122.00	1
6	104.00	122.00	200.00	120.00	1
7	92.00	114.00	200.00	114.00	2
8	36.00	96.00	60.00	96.00	2
9	60.00	96.00	86.00	111.00	2
10	.00	92.00	200.00	92.00	3
11	.00	86.00	200.00	86.00	4
12	.00	81.00	200.00	81.00	5

ISOTROPIC SOIL PARAMETERS
6 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	200.0	37.0	.00	.0	1
2	120.0	120.0	150.0	20.0	.00	.0	1
3	120.0	120.0	150.0	20.0	.00	.0	1
4	120.0	120.0	.0	36.0	.00	.0	1
5	140.0	140.0	5000.0	36.0	.00	.0	1
6	130.0	130.0	200.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	96.00
2	50.00	96.00
3	60.00	98.00
4	76.00	104.00
5	120.00	115.00
6	200.00	120.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

2500 TRIAL SURFACES HAVE BEEN GENERATED.

50 SURFACES INITIATE FROM EACH OF 50 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = .00

AND X = 60.00

EACH SURFACE TERMINATES BETWEEN X = 100.00
AND X = 200.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

1
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Midvale UT s/n5206

FAILURE SURFACE # 1 SPECIFIED BY 14 COORDINATE POINTS

SAFETY FACTOR = 1.459

X-CENTER = 54.68
Y-CENTER = 172.87
RADIUS = 86.09

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	15.92	96.00	-23.43
2	25.09	92.02	-16.77
3	34.67	89.14	-10.11
4	44.51	87.38	-3.46
5	54.50	86.78	3.20
6	64.48	87.34	9.86
7	74.33	89.05	16.52
8	83.92	91.89	23.18
9	93.11	95.83	29.84
10	101.79	100.81	36.50
11	109.83	106.75	43.16
12	117.12	113.59	49.81
13	123.57	121.23	56.47
14	123.81	121.59	

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION   Richardson A-A' - 30' X 10' Buttress

BOUNDARY COORDINATES

6 TOP BOUNDARIES
12 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	96.00	29.00	96.00	2
2	29.00	96.00	59.00	106.00	6
3	59.00	106.00	79.00	106.00	6
4	79.00	106.00	92.00	114.00	2
5	92.00	114.00	104.00	122.00	1
6	104.00	122.00	200.00	120.00	1
7	92.00	114.00	200.00	114.00	2
8	29.00	96.00	60.00	96.00	2
9	60.00	96.00	79.00	106.00	2
10	.00	92.00	200.00	92.00	3
11	.00	86.00	200.00	86.00	4
12	.00	81.00	200.00	81.00	5

ISOTROPIC SOIL PARAMETERS

6 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	200.0	37.0	.00	.0	1
2	120.0	120.0	150.0	20.0	.00	.0	1
3	120.0	120.0	150.0	20.0	.00	.0	1
4	120.0	120.0	.0	36.0	.00	.0	1
5	140.0	140.0	5000.0	36.0	.00	.0	1
6	130.0	130.0	200.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	96.00
2	50.00	96.00
3	60.00	98.00
4	76.00	104.00
5	120.00	115.00
6	200.00	120.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

2500 TRIAL SURFACES HAVE BEEN GENERATED.

50 SURFACES INITIATE FROM EACH OF 50 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = 60.00
AND X = 80.00

EACH SURFACE TERMINATES BETWEEN X = 100.00
AND X = 200.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

FAILURE SURFACE # 1 SPECIFIED BY 6 COORDINATE POINTS

SAFETY FACTOR = 1.455

X-CENTER = 87.38
Y-CENTER = 126.11
RADIUS = 24.00

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	74.29	106.00	-21.04
2	83.62	102.41	3.01
3	93.61	102.93	27.06
4	102.51	107.48	51.11
5	108.79	115.27	75.16
6	110.54	121.86	

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION Richardson A-A' - 3:1 Fill Slope

BOUNDARY COORDINATES

3 TOP BOUNDARIES
11 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	96.00	26.00	96.00	2
2	26.00	96.00	104.00	122.00	6
3	104.00	122.00	200.00	120.00	1
4	92.00	114.00	104.00	122.00	1
5	92.00	114.00	200.00	114.00	2
6	26.00	96.00	60.00	96.00	2
7	60.00	96.00	76.00	104.00	2
8	76.00	104.00	92.00	114.00	2
9	.00	92.00	200.00	92.00	3
10	.00	86.00	200.00	86.00	4
11	.00	81.00	200.00	81.00	5

ISOTROPIC SOIL PARAMETERS

6 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	200.0	37.0	.00	.0	1
2	120.0	120.0	150.0	20.0	.00	.0	1
3	120.0	120.0	150.0	20.0	.00	.0	1
4	120.0	120.0	.0	36.0	.00	.0	1
5	140.0	140.0	5000.0	36.0	.00	.0	1
6	130.0	130.0	200.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 6 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	96.00
2	50.00	96.00
3	60.00	98.00
4	76.00	104.00
5	120.00	115.00
6	200.00	120.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

2500 TRIAL SURFACES HAVE BEEN GENERATED.

50 SURFACES INITIATE FROM EACH OF 50 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 60.00

EACH SURFACE TERMINATES BETWEEN X = 100.00
AND X = 200.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

1
AGEC
Midvale UT s/n5206

FAILURE SURFACE # 1 SPECIFIED BY 13 COORDINATE POINTS

SAFETY FACTOR = 1.472

X-CENTER = 49.58
Y-CENTER = 167.70
RADIUS = 81.41

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	11.02	96.00	-24.75
2	20.10	91.81	-17.71
3	29.63	88.77	-10.67
4	39.46	86.92	-3.62
5	49.44	86.29	3.42
6	59.42	86.88	10.46
7	69.25	88.70	17.50
8	78.79	91.71	24.55
9	87.88	95.86	31.59
10	96.40	101.10	38.63
11	104.22	107.34	45.67
12	111.20	114.50	52.71
13	116.71	121.74	

2500 TRIAL SURFACES HAVE BEEN GENERATED.

50 SURFACES INITIATE FROM EACH OF 50 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 60.00

EACH SURFACE TERMINATES BETWEEN X = 100.00
AND X = 200.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

1
AGEC
Midvale UT s/n5206

FAILURE SURFACE # 1 SPECIFIED BY 9 COORDINATE POINTS

SAFETY FACTOR = 1.415

X-CENTER = 79.76
Y-CENTER = 137.36
RADIUS = 48.15

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	55.10	96.00	-24.85
2	64.18	91.80	-12.93
3	73.92	89.56	-1.01
4	83.92	89.39	10.91
5	93.74	91.28	22.84
6	102.96	95.16	34.76
7	111.17	100.86	46.68
8	118.03	108.14	58.60
9	120.74	112.57	

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION Richardson B-B

BOUNDARY COORDINATES

5 TOP BOUNDARIES
9 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	96.00	60.00	96.00	2
2	60.00	96.00	110.00	112.00	2
3	110.00	112.00	148.00	114.00	2
4	148.00	114.00	169.00	124.00	1
5	169.00	124.00	200.00	124.00	1
6	148.00	114.00	200.00	114.00	2
7	.00	92.00	200.00	92.00	3
8	.00	86.00	200.00	86.00	4
9	.00	81.00	200.00	81.00	5

ISOTROPIC SOIL PARAMETERS

5 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	200.0	37.0	.00	.0	1
2	120.0	120.0	150.0	20.0	.00	.0	1
3	120.0	120.0	150.0	20.0	.00	.0	1
4	120.0	120.0	.0	36.0	.00	.0	1
5	140.0	140.0	5000.0	36.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	96.00
2	60.00	96.00
3	92.00	106.00
4	200.00	124.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.